A MANUAL OF COAL MEASURE PALÆONTOLOGY

BY

T. P. BARKAS F.G.S.

ILLUSTRATED GUIDE

TO THE

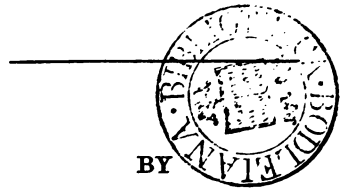
FISH, AMPHIBIAN, REPTILIAN,

AND SUPPOSED

MAMMALIAN REMAINS

OF THE

NORTHUMBERLAND CARBONIFEROUS STRATA.



BY

THOMAS PALLISTER BARKAS, F.G.S.

LONDON:
W. M. HUTCHINGS, 5, BOUVERIE STREET, FLEET STREET, E.C.

1873.

To the Working Miners in Northumberland, who have rendered me essential service during my researches into the Fauna of the Northumberland Coal Measures.

MY DEAR FRIENDS,

It is with extreme pleasure that I take the liberty of dedicating to you the present work on Coal Measure Vertebrata, which is based upon recent discoveries in the Fauna of the Northumberland Coal Measures. For the greater part of the discoveries described I am indebted to a few Working Miners, the names of some of whom appear in the substance of this work. You, at great sacrifice of time, and with much self-denying labour, gratuitously furnished me with the opportunity of examining specimens, some of which it would have been impossible to have obtained for examination had they not been procured by your continuous, careful, and painstaking observations and investigations. Your occupation is in the series of Geological Strata from which has been, and is now being obtained, the chief material source of England's greatness, and from which also have been, and, I believe, will yet be obtained, many of the most instructive and suggestive remains of Early World life.

I am, very sincerely,

Your obliged fellow-labourer,

T. P. BARKAS.

Newcastle-on-Tyne, January 1, 1873.

PREFACE.

THE following chapters were in substance originally published in the pages of the *Colliery Guardian;* but the number of applications I have received to publish them in a separate volume has induced me to issue them in the form in which they are now presented. This work does not in any sense pretend to be exhaustive of the subject upon which it treats, but is rather a preliminary monograph of the Carboniferous Fauna of one locality, that locality being the Carboniferous Strata of South Northumberland.

I have endeavoured, as concisely as possible, to give descriptions and illustrations of the leading remains of Fishes, Labyrinthodonts, and Reptiles that have come under my own observation, and have refrained as much as possible from any attempt at generalisation, because all such attempts must yet be premature, as the discoveries that have yet been made, judging by the discoveries that are now almost daily being made, bear but a small proportion to those that will probably occur within a very limited period.

Nearly all the discoveries of Amphibians and Reptilians in the British Carboniferous Strata have occurred within the last dozen years, and it is not improbable, judging by the rapid progress of recent years, that during a similar limited period our knowledge of the remains of Coal Measure Batrachians and Reptilians may be quadrupled; and with such additional means at the disposal of palæontologists, some approximately satisfactory classification may be possible and desirable.

I desire my readers to recognise the following pages as mere helps to their own investigations, and I shall be glad at any time to have an opportunity of examining specimens from other Carboniferous localities, and shall be most happy

in return to afford enquirers opportunities of examining specimens, typical or otherwise, that are in my possession. My object is to promote a knowledge of Carboniferous Fauna, by stimulating miners and others, who have peculiar facilities, to search for and preserve such specimens as may be obtained in their respective localities.

I have, during the progress of my investigations into Coal Measure Fauna, which have now extended over five years, been much indebted to Messrs. Simm and Taylor, of West Cramlington, and Mr. J. Salt, of Newsham, all of whom have kindly placed their large and valuable collections of fossils at my disposal; and the two former of whom have kindly, in addition to the use of their fossils, prepared for me gratuitously nearly all the microscopical sections which appear in the various plates that illustrate this work.

I am also indebted to Mr. John Ward, of Longton, Staffordshire, for the great privilege of examining, on two occasions, the whole of his immense collection of Coal Measure fossils. My thanks are due, and are heartily given, to Mr. Davis, of the British Museum, and Mr. Etheridge, of the Jermyn-street Museum, to both of whom I am greatly indebted for most valuable information communicated to me respecting the fossils in the respective National Collections with which they are associated.

With the exception of figs. 186, 190, 191, and 202, the whole of the illustrations are original, and were taken from fossils in my own cabinet, or selected from the cabinets of Messrs. Simm, Taylor, and Salt.

I deem it a duty to state that very valuable information respecting the Fishes and Labyrinthodonts of the Northumberland Carboniferous Strata may be had by an examination of several papers published by Messrs. Hancock and Atthey, in the "Annals and Magazine of Natural History," and in the "Transactions of the Tyneside Naturalists' Field Club," to which papers I am indebted for much useful information.

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ILLUSTRATED GUIDE

TO THE

FISH, AMPHIBIAN, REPTILIAN, AND SUPPOSED MAMMALIAN REMAINS

OF THE

NORTHUMBERLAND CARBONIFEROUS STRATA.

Chapter I.

PRELIMINARY.

One of the greatest palæontological desiderata of the present day is an illustrated manual of coal-measure faunæ, and especially of those departments which embrace the Fishes, Amphibia, Reptilia, and supposed Mammalia of the Carboniferous era.

We are at this time absolutely without a manual of any kind which, in itself, would be of service in the interpretation of the fish and reptile remains that are daily added to the cabinets of the comparatively few palæontologists, in different parts of the kingdom, who are earnestly investigating the life history of the Carboniferous period.

There are few books on palæozoic palæontology which do not afford some aid, but many of the works are so expensive and inaccessible to the vast majority of palæontologists as to place them practically beyond their reach. There are many works containing both descriptions and illustrations of some

of the fish and reptile remains of our coal strata, but, in addition to the works themselves being generally inaccessible, the information respecting the carboniferous fossils is so scattered throughout their pages as to require more years for their discovery and comprehension than are at the command of many of those who possess specimens, but who have neither time, opportunities, nor perseverance to enable them to search for the information which may, with great labour and difficulty, be found in their pages. To all such a brief, popular, and fully illustrated manual would be invaluable.

As a preliminary contribution to a more complete manual, I devote this series of chapters to a descriptive monograph of the Fishes, Amphibia, Reptilia, and supposed Mammalia of our Northern Coal Measures, illustrated by careful drawings from specimens in my own possession, and such as I have obtained from the cabinets of gentlemen who are engaged in the investigation of the same department of palæontology.

My investigations have been devoted, for the most part, to the collieries of Northumberland, and from them, aided by such specimens as I have been able to procure from other collectors, these chapters are illustrated.

An appeal to the eye through the direct instrumentality of drawing often affords more aid to the interpretation of fossils than do the most elaborate and accurate descriptions; and the careful and numerous drawings which accompany these chapters will, I trust, compensate for the deficiencies in the descriptions of the fossil forms, which are so complex as to be almost incapable of a description that shall be comprehensible to the uninitiated.

The fossils described and illustrated are, for the most part, from a stratum of shale, known as the Low Main Coal Shale. It immediately over-lies the Low Main Coal Seam, and varies in thickness and richness of fossil remains in different parts of the coal fields of Northumberland. The average depth of the Low Main Seam along the margin of the ocean in South Northumberland is about 100 fathoms, but it gradually rises

towards the surface, and crops out a few miles from the coast westward, and near the River Coquet northward.

In the county of Durham, the seam known as the Low Main in Northumberland is recognised as the Hutton Seam, and there, also, fish remains, resembling those discovered in Northumberland, have been found, but not in large quantities. So far as I am aware, no thorough investigation of the shale associated with the Hutton Seam has yet been instituted.

I have recently had the pleasure of examining a very fine large fish tooth, from the shale which over-lies the Hutton Seam, and I have now good reason for believing that that stratum will not much longer remain uninvestigated.

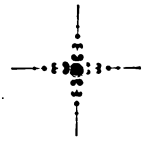
The fishes of the Coal Measures may be divided into two classes, viz., the Selachians, or fishes without gill-plates, and with cartilaginous skeletons, of which Sharks are the living representatives; and the Ganoids, or those that have opercular plates, but only partly ossified skeletons, which are represented by Polypterus and Lepidosteus of African and American rivers. The Teleosts, or true bony fishes, similar to the salmon or herring of the present day, have not yet been discovered in formations of the antiquity of the Palæozoic.

In addition to the descriptions and illustrations which are supplied by these chapters, references are given to the principal works in which the fossils enumerated have been described, and especially those in which they have been figured. The following is a list of the works which contain valuable information, and to some of which references will be made. Students are referred to the following works for fuller information than can possibly be given in a brief and essentially popular local guide:—

M. Agassiz "Poissons Fossiles," 10 vols. ... ... "*A. P. F.*"
M. Agassiz "Poissons du Vieux Grès Rouge" ... ... "*A. P. G. R.*"
"American Journal of Science and Arts," Series I. and II. "*A. J. S. A.*"
"Annals and Magazine of Natural History" ... ... "*A. N. H.*"
Buckland's "Geology and Mineralogy" ... ... "*B. G. M.*"

"The Colliery Guardian" ... ... "*C. G.*"
Cuvier's "Recherches sur les Ossamens Fossiles" ... ... "*C. R. O. F.*"
Dana's "Manual of Geology" ... ... "*D. M G.*"
Dawson's "Air Breathers of the Coal Period" ... ... "*D. A. C. P.*"
Dawson's "Acadian Geology" ... ... "*D. A. G.*"
De La Beche's "Geological Observer" ... ... "*B. G. O.*"
Dr. Deane's "Ichnographs from the River Connecticut"... "*D. I. C.*"
"The English Mechanic" ... ... "*E. M.*"
"Fossil Footprints in the Red Sandstones of Pottsville, Pennsylvania," by Lea ... ... "*F. F. L.*"
"Geology and Palæontology of Illinois" ... ... "*G. P. I.*"
"Geological Magazine" ... ... "*G. M.*"
"The Geologist" ... ... "*T. G.*"
Hitchcock's "Outlines of the Geology of the Globe" ... "*H. O. G. G.*"
Home's "Lectures on Comparative Anatomy" ... ... "*H. L. A.*"
Huxley and Hawkins' "Atlas of Comparative Osteology" "*H. H. O.*"
Huxley's "Elements of Comparative Anatomy" ... ... "*H. C. A.*"
Huxley's "Classification of the Animal Kingdom"... ... "*H. C. A. K.*"
"Ichnology of New England," by Professor Hitchcock ... "*I. H.*"
"Ichnology of Annandale," by Sir W. Jardine ... ... "*I. J.*"
King's "Permian Fossils"... ... ... "*K. P. F.*"
"Memoirs of the Geological Survey" ... ... "*M. G. S.*"
Meyer, Hermann von, "Reptilien aus der Steinkohlen-Formation in Deutschland."
Miller's "Old Red Sandstone" ... ... "*M. O. R.*"
Miller's "Sketch Book of Popular Geology" ... ... "*M. P. G.*"
Miller's "Footprints of the Creator" ... ... "*M. F. C.*"
Miller's "Testimony of the Rocks" ... ... "*M. T. R.*"
Morris's "British Fossils"... ... ... "*M. B. F.*"
Munster's "Beitrage zur Petrefactenkunde" ... ... "*M. B. P.*"
Owen's "Dental Characteristics of Genera and Species of Coal-Measure Fishes and Reptiles" ... ... "*O. D. C.*"
Owen's "Odontography" ... ... "*O. O.*"
Owen's "Palæontology" ... ... "*O. P.*"
Owen's "Homology of the Vertebrate Skeleton" ... ... "*O. H.*"
Owen's "Comparative Anatomy and Physiology of the Vertebrata" ... ... "*O. C. A.*"
Owen's "Fossil Mammalia" ... ... "*O. F. M.*
Page's "Handbook of Geology"... ... ... "*P. G.*"
Pander's "Silurian and Devonian Fishes" ... ... "*P. S. D. F.*"
"Philosophical Transactions of the Royal Society" ... "*P. T. R. S.*"
"Proceedings of the North of England Institute of Mining Engineers" ... ... "*P. M. E.*"

"Proceedings of the Palæontographical Society"	"*P. P. S.*"
"Reports of the Proceedings of the British Association" ...	"*R. B. A.*"
"Quarterly Journal of the Geological Society"	"*Q. J. G. S.*"
"Scientific Opinion"	"*S. O.*"
Sedgwick and M'Coy's "British Palæozoic Fossils" ...	"*S. M. B. P. F.*"
"Transactions of the Royal Society of Edinburgh" ...	"*T. R. S. E.*"
"Transactions of the Royal Irish Academy"	"*T. R. I. A.*
"Transactions of the Geological Society"	"*T. G. S.*"
"Transactions of the Manchester Geological Society" ...	"*T. M. G. S.*"
"Transactions of the Tyneside Naturalists' Field Club" ...	"*T. N. F. C.*"



Chapter II.

CARBONIFEROUS SELACHIANS.

During the Palæozoic period, when our coal strata were being deposited, there existed a class of fishes which have only a limited number of representatives among the modern inhabitants of the deep. They belong to the section known as Selachians, and were characterised by the possession of fin spines of formidable proportions, of teeth which were for the most part compound, of tubercles which bear a considerable resemblance in structure to modern dentinal apparatus, but which bear a still stronger resemblance to the small spines which cover the shagreen-like skin of modern Sharks. The coal measure Selachians are, in fact, related to the modern Sharks by the possession of cartilaginous skeletons, of pavement-like or moveable teeth, of spines for the purposes of defence or motion, and of tubercles, which give the surfaces of their bodies a rasp-like roughness. Negatively, they resemble modern Sharks by not having either operculæ or scales.

Coal measure Selachians, unlike the Ganoids of the same period, are never found in a perfect, or approximately perfect condition, their cartilaginous endo-skeletons rendering such preservation of their forms apparently impossible, except on the supposition that the fishes died in perfectly still water, that their remains were gradually embedded in the mud which forms the shale in which they are now found, and that they were undisturbed by any subsequent motion of the water, or by the interference of other animals inhabiting the same waters. All these hypotheses are improbable. The least motion of the water would, when the decomposition of the cartilaginous skeleton had advanced, release the teeth, spines, tubercles, and other bony portions of the fish, and scatter them about promiscuously over the surface of the

mud on which the waters rested. Such, indeed, appears to have been the fact, as all that is yet known of these cartilaginous coal measure fishes has relation to their teeth, spines, and tubercles; and to the illustrations and descriptions of those that have been found in Northumbrian strata the attention of palæontological and practical coal mining readers is specially solicited.

It has long been a matter of regret that fossil searching has not formed a portion of the recreation or study to which intelligent viewers and working miners have devoted their leisure hours in their various localities. In all districts where close search has been made, fish, reptile, and other remains of a most interesting and valuable description have been found, and if the illustrations here described serve to direct the attention of practical miners and inquiring men to the importance of palæontology as a means of revealing the Biological history of our globe, and indicate the pleasure to be derived from its study, I shall be amply repaid for any trouble I may have taken in the preparation of these popular chapters. A more general investigation of the coal strata would, doubtless, be the means of adding several new genera and species of Fishes, Amphibia, Reptilia, and, probably, of Mammalia to the already large numbers which furnish the shelves of the chief Museums in the Kingdom, and especially the private cabinets of a few provincial and comparatively unknown palæontologists.

The genera are arranged in the order of their rarity, commencing with those that are most abundant, and terminating with those that are most rare, in the Northumberland True Coal Measures.

GYRACANTHUS.

Of the genus *Gyracanthus*, there are several species. They are known by spines, carpal bones, and tubercles. The spines are of large size, the pectoral spines, which are paired, being much the larger, varying in length from 8 in. to about

2 ft., the average length being 12 in. The commonest species is *Gyracanthus tuberculatus*. There is considerable reason for believing that the fish was a ground fish, inasmuch as the pectoral spines represented by fig. 1 are almost invariably worn at their distal extremities, while the dorsal spines, fig. 2, have their apices generally perfect. The dorsal spines are denticulated on the inner or concave edge. The grooves or markings on the bodies of the spines are oblique or gyrating, hence the generic name of the fish. The spines are hollow, and of very open structure, as may be seen by fig. 3, which illustrates a transverse section of a dorsal spine. Fig. 4 represents a tubercle of *Gyracanthus*, natural size, and fig. 5, the same tubercle, magnified ten diameters. These tubercles are undoubtedly those of *Gyracanthus*, being frequently found in great numbers associated with other remains of the fish, but it is extremely probable that similar tubercles belong to the more rare Selachian, *Ctenacanthus*, with the remains of which they are not unfrequently found. The son of Professor Agassiz, during his recent visit to England, informed me that his father had recently discovered a ground fish in the River Amazon, which had spines that much resembled those of *Gyracanthus*, and that the pectoral spines were worn in a manner resembling the pectoral spines of *Gyracanthus*, thus confirming the opinion of Messrs. Kirkby and Atthey, who were the first to suggest the theory that the wearing of the distal extremities of the pectoral spines of *Gyracanthus* was caused by the fish dragging them along the ground during its progress through the water.*

DIPLODUS.

Of this fish the teeth alone are certainly known; they are of many sizes, and have marked external and internal peculi-

* Information respecting *Gyracanthus* may be obtained by referring to *A. P. F.*, vol. iii., table I*, 5, 7; *T. N. F. C.*, vol. iii., new series, pp. 108, 111; *S. M. B. P. F.*, p. 629; *K. P. F.*, p. 321; *P. G.*, p. 220; *D. A. G.*, p. 210.

arities. They vary in size from $\frac{3}{4}$ in. to $\frac{1}{8}$ in.; the commoner large forms being *Diplodus gibbosus*, and the small forms, *D. minutus*. Fig. 6 illustrates the external aspect of a large form of natural size; fig. 7 the side aspect of the same; fig. 8 is *D. minutus;* fig. 9, a longitudinal section of a large form of *Diplodus* magnified two diameters; fig. 10, a section of side view, magnified three diameters; fig. 11, a section taken obliquely, the base of the tooth and the middle denticle being rubbed away; fig. 12, a section taken obliquely across the two chief denticles, enlarged eight diameters; fig. 13, a similar section of another specimen, and fig. 13* illustrates a rare form of *Diplodus* with two large dentinal processes, and three small intermediate ones. This form is very rare, the usual forms having two large and one small process. It will be seen that the structures of figs. 9 and 10 differ from those of 11, 12, and 13, and this is not the result of the line of section, but of the absolute structures of the teeth, which apparently belong to different species of the same genus. The tooth represented by fig. 10 was described by Professor Owen as *Pternodus productus*, and fig. 13 as *Ochlodus crassus;* they are, however, without doubt *Diplodi.**

PLEURACANTHUS.

Of this genus, nothing is positively known, except the spines, and even they are supposed to belong to *Diplodus;* but evidence is not yet sufficient to justify anyone in speaking conclusively as to their relationship to that fish. For the present, we shall assume that they form an independent genus. The spines of *Pleuracanthus* vary in length from three or four inches to one foot; they are oval in section, have a bright and somewhat smooth appearance, and are marked near the bases by slight longitudinal grooves. On each spine, there are two long rows of well developed denticles,

* See *A. P. F.*, vol. iii., table M^2, 22^b; *T. N. F. C.*, vol. iii., pp. 111, 115; *S. O.*, vol. iii., p. 17; *D. A. G.*, p. 211; *G. S. I.*, plate 4.

which divide the spine into two nearly equal parts. Fig. 14 illustrates an external view of a spine of *Pleuracanthus* of natural size; fig. 15, a transparent section of the same, showing the central pulp cavity; fig. 16 represents a transverse section magnified six diameters.*

CTENOPTYCHIUS.

Ctenoptychius, like *Diplodus*, is a genus known only by its teeth, which are of various and elegant forms, the typical specimens being those represented by figs. 17 to 23. Figs. 17, 18, 19, are different varieties of *C. pectinatus;* fig. 20, with denticles varying from twenty-four to thirty in number, is *C. denticulatus;* fig. 21 is *C. apicalis*, only one specimen of which I have found in the Northumberland Coal Measures, while of those previously mentioned I have found hundreds. Fig. 22, six specimens of which I have found, have lateral instead of basal roots. Fig. 23, one specimen of which has alone been found, is also an exceptional form. It is assumed that these fossils are teeth or true oral appendages, but, so far as my investigation has gone, I have not found any in consecutive order. They may be labial or dermal appendages rather than oral, but in the meantime they are recognised as true teeth. Professor Owen described *C. pectinatus* as *Ageleodus diadema.*†

PLEURODUS.

Of this genus, little is known. Fig. 24 illustrates a specimen, natural size, as found in the shale; figs. 25, 27, similar specimens, prepared as sections for microscopic examination, and fig. 26, the same magnified ten diameters. The average

* See *A. P. F.*, vol. ii., table 75; vol. iii., table 45; *G. M.*, vol. 1868, p. 580; *P. G.*, p. 220; *O. P.*, p. 123.

† See *A. P. F.*, vol. iii., table 19; *S. M. B. P. F.*, plate 3 I., fig. 21, p. 626; *O. D. C.*, plate 4, p. 60; *T. N. F. C.*, vol. iii., pp. 115-118; *G. M.*, vol. vi., p. 43; *P. G.*, p. 220; *D. A. G.*, p. 209; *G. S. I.*, plate 4.

long diameter of *Pleurodus* is $\frac{5}{16}$ in., and the average short diameter is $\frac{3}{16}$ in. On one side, the teeth are concave, and on the other very convex, presenting the appearance of compressed mammæ. The minute microscopic structure of these imperfectly understood teeth closely resembles the structure of most of the *Ctenodi*, and especially of *Ctenodus elegans* and *C. tuberculatus*.

PŒCILODUS.

The genus *Pœcilodus*, like *Pleurodus*, is little understood. Fig. 28 is a specimen, natural size, representing the transverse oblique ridges; fig. 29, a section of the same; fig. 30, ditto, magnified ten diameters. The *Pœcilodi* closely resemble the *Pleurodi* in general appearance, the chief difference being that their forms are more elongated, and that they are crossed obliquely by well marked ridges. In internal structure and general appearance, they very closely resemble *Pleurodus*.*

CLADODUS.

It is an open question whether the tooth known as *Cladodus* belongs to *Gyracanthus* or the closely allied and much more rare fish known as *Ctenacanthus*. The balance of evidence appears to point in the direction of the latter fish, and for the following reasons :—Remains of *Gyracanthus* are abundant in our Northern Coal Measures, but the teeth of the genus *Cladodus* are very rare. *Ctenacanthus* spines equal, in rarity, *Cladodus* teeth, and the teeth of *Cladodus* are found associated with the spines of *Ctenacanthus* too frequently to render the hypothesis of coincidence tenable. It is, therefore, extremely probable that the teeth named *Cladodus* belonged to the fish which had the spines of *Ctena-*

* See *S. M. B. P. F.*, plate 3 I., p. 638; *S. O.*, vol. iii. p. 150; *G. S. I.*, plate 8.

canthus. Figs. 31, 32, 33 represent different forms of *Cladodi*, and fig. 34 is an admirable illustration of specimen 33, magnified six diameters.*

CLIMAXODUS.

Of this genus, little is known. Recent writers have attempted to merge it with *Janassa* of Munster, and to remove it from the *Cestracionts* to the *Rays*, but local specimens are, as yet, too imperfect to justify any positive expression of opinion respecting its relationships. The teeth of British specimens of *Janassa* differ in many respects from those of *Climaxodus*, the chief difference being the marked sigmoidal curve of the former and the comparative straightness of the latter. Fig. 35 presents the front aspect of *Climaxodus* of ordinary size and form, and displays the grooves and ridges which characterise its surface; fig. 36 is a back view of a similar tooth, and fig. 37 a side view. The minute structure of the bone of *Climaxodus* is very peculiar; a portion of a section of the root of the tooth is represented, magnified twenty diameters, by fig. 38. The *Climaxodi* vary in length from $\frac{3}{8}$ in. to $1\frac{1}{2}$ in.; they vary also in form and in the depth, number, and undulating character of the transverse ridges.†

ORTHOCANTHUS.

Orthocanthus is known by its spines alone, which are exceedingly rare in our Northern Coal Measures. The specimens vary in size, the largest being $\frac{3}{4}$ in. in diameter, and 15 in. long. They are straight, round, strong, and gradually taper to the distal extremity. The denticulations, unlike those of *Pleuracanthus*, do not divide the spine into two equal portions, but run in two columns along one side of

* See *A. P. F.*, vol. iii., table 22^b; *S. M. B. P. F.*, p. 619; *G. S. I.*, plate 1.

† See *G. M.*, Nov., 1868, p. 496; vol. vi., p. 381; *T. N. F. C.*, vol. iii., pp. 306-8, pp. 330-38; *S. O.*, vol. ii., p. 642; *S. M. B. P. F.*, p. 620.

the spine. Fig. 39 represents a specimen of medium size; fig. 39*, a transverse section of a larger spine; fig. 40, a transverse microscopical section of a smaller spine; fig. 41, the same section magnified eight diameters; and fig. 42, a longitudinal portion of the same spine magnified ten diameters.*

CTENACANTHUS.

Spines of this rare fish are generally obtained in a very fragmentary condition, but that which is represented by fig 43 is nearly perfect and of natural size. Fig. 44 is a transverse section of the same spine, in which the two alæ or wings are represented, extending from the body of the spine. The lower part of fig. 43 represents the body or shaft of the spine; the upper or fragmentary part, the wings. The wing at one side of the spine is attached throughout the entire length of the spine, but that on the upper or presented side is only attached at the proximal and distal extremities, and is free in the centre, apparently for the purpose of allowing space for the infolding of the fin to which it was attached. Fig. 57 illustrates the dorsal spine; the larger specimen, as in the case of *Gyracanthus*, being pectoral. Figs. 45 and 47 are transverse sections of the dorsal spine, natural size, and fig. 46 the same magnified four diameters. Fig. 58 is a much enlarged section of a portion of the same. Fig. 48 is a small dermal tubercle of *Ctenacanthus;* fig. 49, the same enlarged. Fig. 50, a four-fold tubercle; fig. 51, ditto enlarged. Fig. 52, an exceptional double tubercle; fig. 53, ditto enlarged. Fig. 54, a pair of quadruple tubercles anchylosed, and fig. 55, the same magnified twelve diameters. Fig. 56 illustrates a greatly enlarged view of a portion of shale, containing various fragments of fish remains prepared for microscopic examination: *a* is a series of anchylosed tubercles; *b*, the cartilaginous partially ossified remains of

* See *A. P. F.*, vol iii., table 45.

some of the Selachians, probably a portion of the cartilage of *Ctenacanthus*, as it is associated with tubercles that probably belong to that genus of fishes. The other fragments consist of comminuted bones, portions of teeth, &c. Figs. 48 and 49 are tubercles of *Ctenacanthus;* they closely resemble those of the more frequently found Selachian *Gyracanthus*, and were by Professor Owen, in his "Dental Characteristics of Genera and Species of Coal Measure Fishes and Reptiles," described as *Dittodus divergens.**

LEPTACANTHUS.

A few spines of *Leptacanthus* have been found in the Northumberland coal strata; they are, as their name indicates, slender, and are slightly curved and delicately denticulated on the concave side; the average length of a spine being 5 in., and the greatest diameter at the base not exceeding $\frac{1}{8}$ in. Those spines are exceedingly rare, not in the Northumberland Coal Measures only, but in the various coal fields of England, Scotland, and Wales. The teeth, tubercles, and other remains of *Leptacanthus* are as yet unknown, and, like several other Selachians, the genus has been founded on the spines only, which further research may eventually prove belong to some other previously described genus.

* See *A. P. F.*, vol. iii., tables 2, 3, 4; *S. M. B. P. F.*, plate 3 I., figs. 31, 33, plate 2 K., p. 624; *D. M. G.*, p. 319; *P. G.*, p. 220; *D. A. G.*, p. 254; *G. S. I.*, plate 12.

Chapter III.

CARBONIFEROUS GANOIDS.

In Chapter No. II., I have endeavoured, by illustrations and descriptions, to indicate the leading peculiarities of the Carboniferous Selachians. The present chapter is devoted to the Carboniferous Ganoids, or fishes that, unlike the cartilaginous Selachians, have one or more of the following distinguishing characteristics, viz., opercular plates, ossified head bones, ossified vertebræ, ribs, scales, teeth of different sizes in rows, or teeth attached to ossified plates.

The Ganoids of the Northumberland True Coal Measures are *Rhizodopsis*, *Megalichthys*, *Ctenodus*, *Acanthodopsis*, *Palæoniscus*, *Strepsodus*, *Cœlacanthus*, *Platysomus*, *Amphicentrum*, *Pygopterus*, *Acrolepis*, *Cycloptychius*, *Gyrolepis*, *Archichthys*, *Orthognathus*, and probably *Dendrodus*.

The genera are described in the order of their abundance. The majority of the species and specimens described have not previously been figured.

RHIZODOPSIS.

In the "Quarterly Journal of the Geological Society," vol. xxii., page 596, reference is made to *Rhizodopsis*, in an elaborate paper by Dr. Young, of Glasgow, in which the naming of the genus is attributed to Professor Huxley. Fishes of the genus *Rhizodopsis* vary in their size from 5 in. to 8 or 10 in., but in the Northumberland Coal Measures they are generally found in a very fragmentary condition. Occasionally, the greater portion of a fish is found, but when found it is usually so much covered with the matrix as to render its interpretation and outline very difficult, if not impossible. So far as regards the specimens discovered in the Northumberland Coal Measures, they consist chiefly of

maxillæ, premaxillæ, mandibles, scales, and vertebræ. The maxillæ, premaxillæ, and mandibles are of various lengths, varying from $\frac{3}{4}$ in. to 2 in.; they are covered on their outer surfaces with a reticulated ornamental network, which is one of the distinguishing characteristics of the jaws.

Fig. 59 is an incomplete mandible, of natural size, at the anterior extremity of which there is the well-defined large laniary tooth, with a small tooth in front, and numerous small teeth extending posteriorly along the alveolar border. This is the usual condition in which the mandibles are found, but perfect specimens show, in addition to the front laniary teeth, other large teeth, as indicated by the dentition of the figure. I have not found any Northumberland mandibles containing those additional large teeth, but have had an opportunity of examining them in jaws obtained from the Staffordshire coal fields, and now in the possession of Mr. John Ward, of Longton. Fig. 60 represents a perfect maxilla, in which there are many small teeth of uniform size, but an entire absence of large laniary teeth.

Fig. 61 is a premaxilla, which is characterised by a rapid tapering from the anterior to the posterior extremity, and by the possession of many small and one large tooth. Fig. 62 is a posterior extremity of a maxilla, magnified four diameters. Fig. 63 is a transparent section of a premaxilla, magnified two diameters; and fig. 64, the anterior extremity of the same, magnified six diameters, in which the beautiful structure of the jaw, the dentine of the teeth, and the large pulp cavities are well exhibited. Figs. 65 and 66 are scales of *Rhizodopsis*. The scales, which are very numerous in our Northumberland strata, vary in size from $\frac{3}{8}$ in. to $1\frac{1}{4}$ in., but both large and small scales have the ovoid shape, the cycloidal and radial lines, the pittings and the central boss, which distinguish them from those of any other known coal-measure fish. Those scales are erroneously described and figured as *Rhizodus granulatus*, in the "Memoirs" of the Geological Survey of Great Britain and of the Museum of Practical

Geology, in Part III., "Iron Ores of South Wales," p. 222, plate 1, figs. 4, 5, and 6. Fig. 67 represents a mass of scales of *Rhizodopsis* embedded in shale, rubbed down so as to form a transparent section, and magnified three diameters. Fig. 68 is a vertebra of *Rhizodopsis*, of the natural size, and fig. 69 is also a vertebra, forming a transparent section, magnified six diameters.*

MEGALICHTHYS.

This genus is one of the most common, best known, and most widely distributed of the coal-measure fishes. Unlike many of the fishes of the Coal period, it has been found in considerable abundance, having been obtained from the limestone shales of Burdie House and Scremerston, and from the True Coal Measures of Northumberland, Lancashire, and Staffordshire. It appears to have existed in considerable numbers throughout the whole of the Carboniferous period, and its remains are better known and more easily recognised than are those of any other coal-measure fish. The jaws, head plates, and scales of *Megalichthys* are covered by a thick coating of highly polished enamel, which presents a brilliant appearance, and gives the impression that they have been artificially and carefully brightened. Such, however, is not the case, the jaws, scales, and head bones being perfectly bright when first relieved from the matrix. Fig. 70 illustrates a mandible of *Megalichthys* of natural size, the smallest mandibles being about 1½ in. long, and the largest about 8 in.; the teeth are of two sizes, the large laniary being at distant intervals, with numerous small villiform teeth placed between each pair of large teeth. Fig. 71 is a maxilla, also of ordinary size, there being smaller and larger maxillæ, as there are smaller and larger mandibles. The teeth of the maxillæ are

* Further information respecting *Rhizodopsis* may be found in *Q. J. G. S.*, vol. xxii., p. 596; *T. N. F. C.*, vol. iii., new series, pp. 85-92; *M. G. S.*, "Iron Ores of Great Britain," Part III., p. 223, plate 1, figs. 4, 5, 6.

small, numerous, and of uniform size. It was on the inner aspect of a fragment of a maxilla of *Megalichthys*, that Professor Owen founded his supposititious Batrachian, *Parabatrachus Colei*, for particulars respecting which see the "Geological Journal," vol. ix., p. 67, pl. 2, fig. 1. Fig. 72 is a side view of a section of a tooth of a fully developed *Megalichthys*, magnified two diameters, and fig. 73 a section of the same, in the front aspect. Fig. 74 is a transverse section of a large tooth of *Megalichthys* taken near the base, magnified six diameters, showing the central pulp cavity, and the tubuliferous radii, extending from the central cavity to the circumference of the dentine. Transverse sections of the teeth of *Megalichthys*, taken beneath the alveolar border of the jaw, display the labyrinthine structure which is characteristic of the teeth of *Labyrinthodonts*. Fig. 75 illustrates a transverse section of a series of villiform teeth of *Megalichthys*, embedded in a matrix of shale, and magnified eight diameters. Fig. 76 represents a section of seven small teeth, and a portion of the dentary bone of a maxilla of *Megalichthys*, magnified six diameters; and fig. 77 a larger portion of dentary bone of a maxilla, with oblique sections of the small teeth on its upper border. Fig. 78 is a scale of natural size and ordinary form; fig. 79, a thin section of a scale magnified two diameters; fig. 80, a thin section of a small scale, magnified three diameters; and fig. 80*, a section of a scale near the upper surface, exhibiting the ring-like depressions which are characteristic of the scales of *Megalichthys Hibberti*. The markings on the scales of *M. Hibberti* are depressions, those on *M. tuberculatus* and *M. coccolepis* are elevations. Fig. 81 illustrates the semi-cylindrical scales which lie at the roots of the fins of *Megalichthys*, and fig. 82 an ossified vertebral centrum of average natural size, with a large persistent notochord.*

* Further illustrations and descriptions of *Megalichthys* may be seen in *A. P. F.*, tab. 63*, 64, vol. ii.; *S. O.*, vol. iii., p. 470; *M. G. S.*, "Iron Ores of Great Britain," Part III., p. 222, plate 1, fig. 16; *S. M. B. P. F.*, p. 610.

CTENODUS.

The genus *Ctenodus* is, because of its apparent relation to the Red Sandstone *Dipterus*, and the modern Australian fish, *Ceratodus*, one of the most interesting of the palæozoic fishes.

With one doubtful exception, all our knowledge of it is yet fragmentary, and consists of an acquaintance with isolated teeth, operculæ, ribs, sphenoids, and other head bones. The writers of a paper in the "Annals and Magazine of Natural History" have endeavoured to establish a relationship almost generic between *Dipterus* and *Ctenodus*, and that relationship is based upon the supposed discovery of the scales of *C. elegans*. The scales of *Dipterus* are circular and imbricated; the reputed scales of *C. elegans* are parallelogrammatic, with compressed centre and rounded corners. Although nearly 1,000 teeth of *Ctenodus* have been found in the Northumberland Coal Formation, and a large proportion of those teeth of considerable size, and although many teeth of the *Ctenodi* have been discovered in Staffordshire and elsewhere, it is a remarkable fact that, up to the present time, not a single specimen of a large scale has been found at all resembling the reputed scales of *C. elegans*, and there are not any uninterpreted or undescribed scales discovered in the Northumberland or Staffordshire Coal Measures that can with any propriety be assigned to *Ctenodus*. As scales are vastly more numerous than teeth, if 1,000 teeth of scaled fishes have been discovered, and each fish had only four or six teeth, it is surely improbable that all the scales belonging to those fishes would have eluded discovery. The legitimate inference from such a series of facts is that the *Ctenodi* had not scales, and that the discovery of the supposed scales of *C. elegans* is either a misinterpretation or that *C. elegans* differs from all other *Ctenodi*, and should be formed into a new genus closely related to *Dipterus* of Miller.

All that we really know of *Ctenodus* is, that it is more or less closely related to *Dipterus* and *Ceratodus*, and that fishes of the genus had two peculiarly formed mandibular teeth attached to flat mandibular bones; two, four, or more palatal teeth; hollow, well-ossified ribs of various sizes; ossified sphenoid and other head bones; and that the operculæ were large, thick, and strong.

The following species of the genus *Ctenodus* have, with the exception of *C. cristatus*, been established on specimens obtained from the Northumberland coal strata, viz., *Ctenodus tuberculatus*, *C. cristatus*, *C. obliquus*, *C. imbricatus*, *C. elegans*, *C. ellipticus*, *C. concavus*, *C. obtusus*, *C. monoceros*, *C. octodorsalis*, and *C. corrugatus*. *Ctenodus ovatus*, from Derbyshire, and *C. interruptus*, in the York Museum, were founded on specimens from the Midland Coal Measures.

Fig. 83 is an upper or palatal tooth of *C. tuberculatus*, natural size, discovered in the Low Main Coal shale of Newsham Colliery, Northumberland. Fig. 84, a mandibular tooth of the same species attached to the lower jaw, also natural size; *a*, restored extremity; *b*, jaw to which the tooth is anchylosed. Fig. 85, a lower tooth of *C. obliquus* attached to jaw, natural size; *a*, denticulated ridges; *b*, jaw bone. Fig. 86, *C. elegans*, natural size. Fig. 87, *C. monoceros*, so named because of the horn-like process at *a*. Fig. 88, *C. concavus*, somewhat resembling *C. tuberculatus*, but named *concavus* because of its extreme concavity. Fig. 89, *C. ovatus*, from the Derbyshire district, embedded in a matrix of limestone, and the only known specimen of the species. Fig. 90, a large slab of shale, natural size, on which are exposed the following specimens: *a*, the impression of a tooth of *Ctenodus*, with *seven* ridges, all denticulated; *b*, a tooth with *seven* ridges, less denticulated; *c*, another tooth with *five* ridges, much denticulated; *d*, a fourth tooth with *six* ridges, perfectly smooth and free from denticulations; *e*, a portion of bone, probably belonging to the skull or shoulder girdle; *f*, *f*, *f*, ribs of various sizes. From the fact of these remains

being found so closely associated, it may be fairly inferred that all the teeth belonged to one fish, and yet, had the teeth been found separately, they would probably have been ascribed to three different species. Another fact worthy of record is that the group closely resembles a similar group of remains of *Ctenodus* in the British Museum, and that on both of the slabs of shale there are teeth much denticulated and others free from denticulations; the smooth teeth resembling those of *Ceratodus*, and the denticulated, those known as *Ctenodus*.

Fig. 91 is an excellent illustration of a very fine pair of upper teeth, lying *in situ*, continuous with and anchylosed to a flat plate of bone; *a* indicates the uniting plate of bone; the lateral figures are teeth; and *b* indicates a rib of *Ctenodus*. Fig. 92 is a perpendicular transverse section of the ridge of a lower tooth of *C. tuberculatus;* fig. 92*, a perpendicular section of a tip of one of the denticles of the specimen figured 83; fig. 93, a section of *C. elegans*, natural size; fig. 94, the same, magnified six diameters; fig. 95, a section of *C. elegans*, with jaw bone attached, natural size; fig. 96, a longitudinal section of one of the ridges of *C. elegans*, magnified two diameters. Microscopic sections of the teeth of the *Ctenodi* show that they display great diversity in their minute structure; and that where external form, as in fig. 90, would not enable a palæontologist to interpret species, that microscopic sections would afford considerable aid. Fig. 97 is a perfect sphenoid bone of *Ctenodus*, medium size, the largest sphenoids being about 11 in. long; fig. 98, longitudinal section of a portion of a sphenoid bone, natural size; fig. 99, transverse section of a sphenoid, near the base of the rhomboidal plate; fig. 100, rib of *Ctenodus*, natural size; fig. 101, longitudinal section of rib, magnified four diameters; fig. 102, transverse section of rib, showing the central cavity and minute structure, magnified three diameters; fig. 103, section of proximal extremity of rib, natural size; fig. 104, opercular plate of large species of *Ctenodus*, natural size: *a* indicates the hinge edge of the opercle; fig. 105 is a

thin section of a small opercular plate of *Ctenodus*, magnified three diameters, and exhibits the minute structure of the bone.*

ACANTHODOPSIS.

Of this new genus of Coal-measure fishes, little is known, except its peculiar jaws and spines. So far as I am aware, scales of *Acanthodopsis* have not been found, except in one instance, and the absence of subsequent discoveries of its scales in a state of aggregation renders the interpretation put upon the single discovery somewhat doubtful.

Neither vertebræ nor ribs of *Acanthodopsis* have been found, and we may assume, therefore, for the present, that the skeleton was cartilaginous, and as the identification of the scales is doubtful, all that we really know of the fish is based upon its jaws, peculiar dentition, and spines.

The supposed scales of *Acanthodopsis* were stated by their discoverers to resemble those of *Acanthodes*.

The spines certainly resemble those of Acanthodean fishes, and upon the assumption of the resemblance between the reputed scales and spines of *Acanthodopsis* with those of *Acanthodes*, the generic name has been founded. As, however, the dentition of *Acanthodopsis* is unique, is totally different from *Acanthodes*, and unlike that of any known fossil or recent fish, it may fairly be doubted whether the resemblance between the two genera has been sufficiently established to render the name of *Acanthodopsis* scientifically justifiable. Whatever may eventually be the decision of science in reference to the relationships of this unique fish, it is impossible to predict; but, in the meantime, we may rest satisfied with the fact that the only satisfactory information

* Further information respecting this interesting genus may be had in *A. G. R.*, tab. 28*; *A. P. F.*, tab. 23, vol. ii.; Ditto, vol. iii., tab. M, 19; *T. N. F. C.*, new series, vol. iii., pp. 54, 66; *S. O.*, vol. ii., pp. 53, 113, 479, 557; vol. iii., p. 369; *E. M.*, vol. xii., pp. 112, 160; *G. M.*, vol. vi., p. 314, plate IX.

we have respecting it is based upon its jaws and spines, and the spines and transparent microscopical sections of the jaws are for the first time excellently figured in the accompanying plate. Fig. 106 is a mandible of *Acanthodopsis*, natural size, illustrating the peculiar pyramidal teeth which are continuous with the dentary bone; fig. 107, a section of the same with mandibular spine attached; fig. 108, a section of a mandible magnified two diameters; fig. 109, one of the largest pectoral (or dorsal?) spines of *Acanthodopsis;* fig. 110, a transparent section of a smaller spine magnified three diameters.*

PALÆONISCUS.

This is one of our commonest Coal-measure and Permian fishes, and various species of the genus are frequently found nearly perfect in the Magnesian Limestone and in the Permian Marl slate. The specimens found in the Northumberland Coal Measures are generally fragmentary, and, if not fragmentary, are so intermixed with or covered by the matrix as to present very imperfect indications of their general forms. In the Staffordshire Coal Measures, the *Palæonisci* are tolerably abundant, but, in the Northumberland Carboniferous strata, they are comparatively rare. In size, they vary from 2 in. to 8 in., and some of the species have very elegant forms.

Fig. 111 is a jaw of *Palæoniscus*, magnified two diameters; and fig. 112, a scale of the same fish, magnified six diameters; the scales are usually highly polished and slightly striated.†

* For further information, see *Q. J. G. S.*, vol. xxii., p. 470; *T. N. F. C.*, vol. iii., pp. 103-8.

† For additional particulars, refer to *A. P. F.*, tab. 5-14, vol. ii.; *T. N. F. C.*, vol. iii. (New Series), pp. 96-103; *D. M. G.*, p. 374; *P. G.*, p. 212; *O. P.*, p. 161; *S. M. B. P. F.*, p. 605; *K. P. F.*, p. 223.

STREPSODUS.

In *Scientific Opinion*, vol. i., p. 556, I wrote as follows respecting *Strepsodus* :—

"In many of the public museums of England, there are scales which are named as belonging to *Holoptychius*, and several precisely similar scales are in the British Museum and Jermyn-street Museum, marked as *Strepsodus*.

"Great obscurity yet prevails respecting the leading characteristics of this remarkable Coal-measure fish. With two or three exceptions, so far as I am aware, the only fragments of it which have been obtained are teeth and scales, the latter being little more than provisionally recognised, and the former, with very rare exceptions, have been obtained singly and unattached to jaws. Dr. John Young, of Glasgow, in his 'Notes on New Genera of Carboniferous Glyptodipterines,' published in the *Quarterly Journal of the Geological Society*, vol. xxii., figures a tooth of *Strepsodus*, on p. 597, and he describes what was then known of the fish on p. 603. The illustration is too delicate and tapering, and the tooth is not sufficiently reflexed at its apex. Dr. Young states that the teeth vary in size from $\frac{1}{10}$ to $\frac{1}{16}$ of an inch in height, that no skull has been found, and that the fragment of a mandible with which he is acquainted gives no certain indication of the mode of arrangement of the teeth, but that he has no doubt teeth of different sizes occurred in the same jaw.

"In the 'Transactions' of the Tyneside Naturalists' Field Club, vol. vi., p. 234, a jaw of *Strepsodus*, under the name of *Holoptychius sauroides*, is figured. The figure represents an imperfect jaw, the front laniary tooth of which alone exhibits the curve which is so peculiarly characteristic of *Strepsodus*. I am happy to be in a position to set the question of the order of the teeth in the jaw of *Strepsodus* at rest,—that is, so far as regards the species in which the teeth are symmetrically rounded; but as some of the detached teeth, with the

characteristic curve of *Strepsodus*, differ very materially from the majority of those found, by having a deeply indented longitudinal furrow on one or more sides, it is not impossible that further research may prove that two species of *Strepsodus* existed, one having rounded and the other having deeply furrowed teeth.

"During my researches in the Northumberland Coal Measures, I have found scores, probably hundreds, of single teeth of *Strepsodus*, but have not had the good fortune to find a jaw. Mr. Ward, of Longton, has been more fortunate. I had the pleasure of examining his extensive collection of fossils, obtained for the most part from the Staffordshire Coal Measures; he has an almost perfect jaw of *Strepsodus*, in which the order of the teeth is beautifully exhibited. Large recurved teeth, about an inch in length, occur at regular intervals of about an inch from each other, and between each pair of large teeth there are five teeth precisely similar in form to the large teeth, but only one-half the length.

"Scales of *Strepsodus* are not uncommon in the Northumberland coal shales; they somewhat resemble those of *Rhizodopsis*, but are much larger and more nearly circular than are those of that common coal-measure fish. *Strepsodus* scales are not unfrequent in the Scottish, Yorkshire, and Staffordshire coal shales, and it is very probable that all the Fishes, Labyrinthodonts, and Reptiles so abundant in some of the Northumberland and Staffordshire collieries would be found equally, or probably, more abundant in other parts of England were a proper search instituted for them."

Since the foregoing communication was written, I have obtained several jaws of *Strepsodus*, which confirm the opinions therein expressed. Fig. 113 represents a portion of a jaw of *Strepsodus*, with two large and six small teeth, of natural size; fig. 113*, a transverse section of two small teeth of *Strepsodus*, attached to a portion of a jaw on which transverse sections of the tubercules on the surface of the jaw are exposed. Fig. 114, one of the medium size larger teeth

of *Strepsodus*. Fig. 115, section of tooth, two diameters. Fig. 116, one of the smaller teeth. Fig. 117, section of one of the smaller teeth, magnified six diameters. Fig. 117*, transverse section of a tooth of *Strepsodus*, taken near the base and magnified six diameters, showing the entire absence of that convoluted structure of the dentine which is characteristic of *Dendrodus*, and of ordinary Coal-measure *Amphibia* and *Reptilia*. Fig. 118, a scale of *Strepsodus*, medium size. Fig. 119, a vertebra of *Strepsodus*, which differs from those of *Megalichthys*, by being much more slender, and from the vertebræ of *Rhizodopsis*, by being considerably larger.*

CŒLACANTHUS.

The relationships of the genus *Cœlacanthus* with other genera of the *Cœlacanth* family are discussed with great ability and at considerable length by Professor Huxley, in the "Memoirs of the Geological Survey," Decade xii. *Cœlacanthus* is characterised by the possession of hollow fin spines, primary and secondary tails, swim-bladder, polished and ridged, opercular, jugular, and palato-quadrate plates, and slender ovoid scales, with ovoid surface markings. The lengths of the *Cœlacanthi* vary from 3 in. to 10 in. Fig. 120 represents an opercular plate of average natural size. Fig. 121, a jugular plate of ditto. Fig. 121*, a transparent section of a jugular plate, magnified two diameters; fig. 122, a palato-quadrate plate; fig. 123, a scale magnified eight diameters; fig. 124 is an illustration of primary and secondary tails, natural size. Fishes belonging to the following genera —*Cœlacanthus*, *Undina*, *Holophagus*, and *Macropoma*, are characterised by this twofold caudal arrangement. Fig. 124*, mandible of *Cœlacanthus*. Fig. 124*b*, maxilla of ditto.†

* See *T. M. G. S.*, vol. i., p. 167, pl. 5, fig. 12; *Q. J. G. S.*, vol. xx., pp. 597, 603; *S. O.*, vol. i., p. 556, vol. ii., pp. 13, 25, vol. iii., p. 369.

† See *A. P. F.*, tab. 63, vol. ii.; *S. O.*, vol. i., p. 570; vol. ii., p. 25; *M. G. S.*, Decade xii., pp. 6-25; *K. P. F.*, p. 235; *O. P.*, p. 155.

PLATYSOMUS.

Fig. 125[a] represents a scale of *Platysomus* of natural size, and 125[b], the same scale magnified four diameters. It is rather uncertain whether the genus *Platysomus* is represented in our Northern Coal Measures; jaws and other remains of a closely allied fish, *Amphicentrum*, are not rare, but, so far as my investigations have extended, the jaws or teeth of *Platysomus* have not been found in the Northern Coal Measures, while those of *Amphicentrum* are not unfrequent. It is not improbable that the local scales that have been assigned to *Platysomus* in reality belong to *Amphicentrum*, and, until more complete specimens have been discovered, and specially until jaws with the peculiar dentition of *Platysomus* have been found, we may not err in recognising the genus as absent from our local coal measures.*

AMPHICENTRUM.

Fishes of the genus *Amphicentrum* are closely allied in general configuration of body, and in form of scales, to *Platysomus*, *Mesolepis*, and *Pycnodus*, but in dentition they differ from all the genera named. Different species of *Platysomus* have blunt and sharp teeth; *Mesolepis* has ovoid teeth; *Pycnodus*, oval flat teeth, and the teeth of these three genera are detachable from the jaws, while those of *Amphicentrum* are not merely anchylosed to the jaws, but, like those of *Acanthodopsis*, form an integral part of them. The most complete specimens of *Amphicentrum* have been found by Mr. Ward, of Longton, in the Staffordshire Coal Measures, the portions found in the Northumberland Coal Measures being, for the most part, jaws and scales. Fig. 126 represents an upper jaw of *Amphicentrum*, magnified two diameters. Fig. 127, a section of the same, magnified three

* See *A.P.F.*, tab. 15-18, vol. ii.; *S.M.B.P.F.*, p. 614; *K.P.F.*, p. 227, pl. 26.

diameters; fig. 128 a lower jaw or mandible, magnified two diameters; fig. 129, a horizontal section of ditto, magnified three diameters.*

PYGOPTERUS, ACROLEPIS, GYROLEPIS, AND CYCLOPTYCHIUS.

There are four genera of fishes of the Northumberland Coal Measures that closely resemble each other, and differ in many marked characteristics from all other known Palæozoic fishes. The genera are *Pygopterus*, *Acrolepis*, *Gyrolepis*, and *Cycloptychius*. The scales of the first three genera are rhomboidal or lozenge-shaped; they have an average diameter of one-sixth of an inch, and are chiefly distinguished by the character of their surface striations. *Pygopterus* scales are lightly grooved over the surface, in the direction of the longer axes, and, at one extremity, the scales of the species found in Northumberland and Staffordshire are marked by easily distinguished pittings. *Acrolepis* scales resemble those of *Pygopterus* in form and strength, but are marked with deep, broad, waving longitudinal grooves, and are free from pittings. *Gyrolepis* scales are marked by delicate lines, which run in a direction parallel to the sides of the scale. The scales of *Cycloptychius* differ from those of the genera named, and, instead of being rhomboidal, they are cycloidal. They resemble the other scales in size, and are marked with cycloidal striations. The jaws of all the four genera closely resemble each other in dentition, each of them having a long series of teeth of three sizes, and all of the teeth, as is the case with the modern ganoid fishes, *Lepidosteus* and *Polypterus*, being tipped with a beautiful tip of enamel. While the jaws of the four genera resemble each other in dentition, they differ in surface markings. The surfaces of the jaws of *Acrolepis* are covered with coarse tuberculations; the jaws of *Pygopterus* are covered with oblique ridges and furrows; the jaws of *Gyrolepis* with longitudinal grooves; and the

* See *Q. J. S.*, vol. xxii., p. 317; *S. O.*, vol. i., p. 437.

jaws of *Cycloptychius* with interrupted longitudinal ridges, which present a slightly wavy appearance in their course. The leading peculiarities of the jaws and teeth will be best understood by reference to the figures which accompany this description. Figs. 130, a scale of *Pygopterus*, natural size, and magnified six diameters. Fig. 130*, a transparent section of scale of *Pygopterus*, magnified six diameters. Fig. 131, a mandible of *Pygopterus*, natural size, showing the three sizes of teeth and the peculiar surface markings of the jaw. Fig. 132, the three sizes of teeth, magnified eight diameters. Fig. 133, a large tooth magnified twenty diameters, the section being through the centre of the pulp cavity. Fig. 134, a section of a tooth, in which the pulp cavity has not been reached, the section being at one side of the centre of the tooth. Fig. 135, a scale of *Acrolepis*, natural size; fig. 136, ditto, magnified eight diameters, and showing the deep surface markings. Fig. 137, a mandible of *Acrolepis*, exhibiting the tuberculations which cover the entire jaw; fig. 138, three sizes of teeth of *Acrolepis*, resembling those of *Pygopterus*, and also resembling those of *Gyrolepis* and *Cycloptychius*; fig. 139, a section of a tooth of *Acrolepis* from the side of the concave curvature, the concavity producing a compressed appearance beneath the enamel tip. Sections 133, 134, 139 exhibit the enamel tip, so characteristic of these genera. Fig. 140, a scale of *Cycloptychius* magnified two diameters. Scales of *Cycloptychius* more closely resemble those of *Cœlacanthus* than do the scales of any other Coal-measure fishes. In form and dentition, the mandibles of *Cycloptychius* and *Gyrolepis* closely resemble those of *Pygopterus* and *Acrolepis*, and they need not, therefore, be figured.*

* For further information, see *A. P. F.*, vol. i., tab. *D.*, 53, 53*, 54, 55, vol. ii., tab. *H.*, 19, 52; *K. P. F.*, plate 23, 24, 25, pp. 232, 234; *P. I. R. S.*, vol. 1849, pp. 435, 475; *S. O.*, vol. i., p. 495, vol. ii., pp. 193, 320, 536, vol. iii., p. 470; *S. M. B. P. F.*, p. 608; *T. S. N. F. C.*, vol. i., p. 236; *E. M.*, vol. xii., p. 521.

ARCHICHTHYS.

Archichthys is a genus of fishes founded upon large teeth, head bones, opercular plates, &c., discovered in the Northumberland Coal Measures, but respecting which much obscurity yet prevails. Fig. 141 illustrates one of the larger teeth of *Archichthys*, natural size; fig. 142 is a transverse section of the tooth taken near the base, and magnified four diameters.*

ORTHOGNATHUS RETICULOSUS (NOV. GEN.).

The genus *Orthognathus reticulosus* was based upon a very excellent specimen of maxilla and mandible, both of which are figured on the fourth sheet of illustrations. The only complete published description of this new and beautiful genus of Coal-measure fishes is contained in the *English Mechanic*, No. 302, p. 372, and is as follows :—

In the third volume of *Scientific Opinion*, p. 72, I described in the following terms a new form of jaw which was discovered in the Northumberland measures :—

"There has recently come into my possession, obtained from the Northumberland Low Main Coal Shale, a jaw which to me is unique. It is unlike any fish or reptile jaw in my possession, and much unlike any I have seen in Northumberland or elsewhere.

"It is lying upon a slab of shale, which measures 5 in. by 4 in., and the jaw before deposition has been broken into two almost equal parts; the two fragments lie near to each other upon precisely the same plane. The teeth, forms of the fragments, and external markings very closely resemble each other, and the two fragments constitute the greater part of the left mandible of a fish or reptile. The length of the two fragments when united is 4 in., the depth of the mandible near the point of symphysis is $\frac{3}{8}$ in.; it gradually widens

* *A. N. H.*, vol. 5, Series IV., p. 267; *S. O.*, vol. iii., p. 401.

towards the articular extremity, near which it is $\frac{7}{8}$ in. deep; the thickness of the mandible at $\frac{1}{4}$ in. below the alveolar border is $\frac{5}{16}$ in., and its thickness at the lower margin is $\frac{1}{8}$ in. The teeth are arranged in a continuous series of uniform size along the alveolar border, a strong bold ridge is continued along the entire jaw, and the teeth are placed $\frac{1}{8}$ in. behind the projecting ridge. The external surface of the mandible is covered with minute well-defined rugose markings, having the appearance of inosculating ridges, and besides the pits and depressions formed by the frequent union of the ridges, the jaw is covered with more minute pittings that require the use of a highly magnifying lens to render them distinctly visible.

"The teeth are $\frac{1}{12}$ in. long; they are stout, compact and strong, and are placed along the entire jaw at a uniform distance from each other of $\frac{1}{12}$ in. Within a space of one inch there are ten teeth, and the mandible, which is 4 in. long, contains forty teeth of uniform size, placed at uniform distances from each other. The teeth, which are smooth, black, and glistening, are free from longitudinal striæ, except at the roots, where there are slight indications of a plicated structure. The inner part of the jaw, which at one part of the specimen is well exposed, is on its lower and upper portions marked with bold longitudinal lines. The articular extremity of the jaw is absent, and I infer from the general appearance of that portion in my possession that one inch of the mandible is lost, and that the total length of the entire jaw has been 5 in.

"I am unable to say whether the jaw is reptilian or ichthyic. In form and in external markings, it somewhat resembles a very fine lower jaw of *Pteroplax cornuta*, now in my possession, but the teeth differ totally from those of that Coal-measure reptile. The rugose markings on the external surface somewhat resemble those on *Rhizodopsis*, but the teeth and form of the mandible differ extremely from those of that well-known fish. The mandible most closely resem-

bles the form of the maxilla of *Megalichthys*, and the rugose structure somewhat resembles the markings on the jaws and scales of *Megalichthys* when they have been stripped of their external coat of enamel.

"Those are the facts as far as regards resemblances, but the differences are so manifest that any person acquainted with carboniferous palæontology would be able to recognise the distinctions at a glance. On the slab containing the mandible there are a few scales of *Cœlacanthus* and a rib, apparently of *Ctenodus*, but to neither of these fishes can the mandible be ascribed.

"For the present I leave the question of its identification open, and hope that some additional remains may eventually enable me to interpret a fossil which, although beautifully exposed and well defined, presents to me as yet an unsolved problem."

After quoting the foregoing in the *English Mechanic*, Jan. 6, 1871, p. 372, I remarked:—

"It will be seen that on that occasion I did not venture upon the expression of any very precise opinion respecting the fossil in question, but merely indicated what jaws it to some extent resembled, and in what respect it differed from them.

"I am now, through the kindness of my friend, Mr. John Simm, of West Cramlington, in a position to express a more definite opinion. When looking over his excellent collection of Coal-measure fossils a few weeks ago, I saw what appeared to me to be a novel form of mandible, and by his kind permission I had the opportunity of removing it for comparison with those in my possession. On comparison I found that it very closely resembled in size, striation, and arrangement of teeth, and on the surface markings of the dentary bone, the jaw above described. As the two jaws resemble each other, not only in dentition and surface markings, but also in size, and as both were found in the same locality and are, so far as I am aware, the only jaws of the kind that have been

found, I think the facts fairly justify me in supposing that they belonged to one fish, or at least to fishes of the same genus.

"Since I have had the privilege of comparing the two specimens, the balance of evidence appears to be in favour of the specimen represented by Fig. 143, because of its form and the absence of laniary teeth, being a maxillary bone, and that represented by Fig. 144, because of its form and the presence of a laniary tooth at the anterior extremity, being a mandible. The only other alternative is that it is a premaxilla, but the straightness of the specimen and its great length render such a hypothesis very improbable. Believing that the jaws belong to an unrecorded genus of fishes, I name them, in accordance with their chief characteristics, *Orthognathus reticulosus*."

Since the publication of the foregoing description, I have obtained another mandible of the same rare fish. Except the jaws, nothing whatever is yet known, and, as many years' search in the Northumberland Coal Measures has only brought to light three specimens, it is not improbable that a long period may elapse before we are enabled to determine the form of the fish, its scales, or its relation to other fishes of the Coal period.* Fig. 143 represents a maxilla of natural size, and fig. 144 a mandible. The surface markings of the jaws, and the order and symmetrical arrangement of the teeth, all indicate that maxilla and mandible belonged to a fish of the same genus.

RHIZODUS.

The genus *Rhizodus*, so common in the shales of the Carboniferous Limestone formation, has not yet been found in the upper or true Coal Measures of Northumberland or else-

* Since this was written, my friend, Mr. John Simm, of West Cramlington, has obtained a very excellent fragment of a maxilla of this rare and little known fish.

where. *Rhizodus* is profusely illustrated by specimens on the shelves of the British Museum, the Jermyn Street Museum, and the University Museum, Edinburgh, where specimens of the massive jaws, huge canine teeth, strong headbones, and thick and deeply pitted scales are to be seen in great numbers. The largest teeth are at least $6\frac{1}{2}$ in. long, and are strong in proportion, and the jaws, headbones, and scales of this predaceous monster of the early Carboniferous period are large and strong in proportion to the size of the teeth. The figures annexed illustrate specimens from the Carboniferous Limestone shales near Berwick-upon-Tweed; and for the specimens I am indebted to Messrs. Spowart, two working miners, who obtained them while working in that locality. Fig. 145 is a tooth of *Rhizodus Hibberti*, natural size; fig. 146 is a transverse section of ditto from near the apex of the tooth; fig. 147 is a tooth of *R. lanceiformis*, natural size, and fig. 148 a transverse section showing the lanceolate form of one side of the tooth.

The bones of *Rhizodus*, which are generally recognised as belonging to a fish, are, notwithstanding, exceedingly enigmatical; and, as nearly twenty genera of large Coal Measure Labyrinthodonts and Reptiles have been discovered since the remains of *Rhizodus* were first found, they point to the not improbable conclusion that *Rhizodus* remains probably belong to Labyrinthodonts.

Some of the uninterpreted bones of the shoulder girdle of *Rhizodus* resemble in everything, except size, similar bones obtained from the Northumberland Coal Measures; and as the bones referred to have the reticulated surfaces which are characteristic of the majority of Labyrinthodont bones, it is not improbable that they also are Labyrinthodont, and not, as was originally supposed, piscine.

Chapter IV.

NEW, OBSCURE, AND UNINTERPRETED FISH REMAINS.

In the previous chapters I have directed attention to those ichthyic remains, from the Northumberland Carboniferous strata, which have been more or less satisfactorily interpreted, and specimens of the majority of which are to be found in a considerable number of public and private collections of Carboniferous fauna in various parts of the United Kingdom. I now propose briefly to call attention to what appear to me to be for the most part remains of Fishes, several of which are new, some of which are obscure, and others of which are as yet uninterpreted.

Fig. 149 is an illustration of a unique specimen of a fragment of a fish jaw in my possession, of natural size. The large laniary tooth is brilliantly glossy; the transverse section of the tooth is polygonal, there being numerous ridges, with flat intermediate spaces. The small villiform teeth pass in front of the larger tooth, and proceed along the alveolar border both anteriorly and posteriorly in a line coincident with the position of the laniary tooth. The dentigerous bone, to which the teeth are attached, is covered with beautiful reticulations, not much unlike those on the jaws of *Rhizodopsis*, but the dentition, as will be seen by those conversant with Carboniferous palæontology, differs from that of any previously described Coal-measure fish. Fig. 150 is the same fragment of jaw and teeth magnified four diameters. Fig. 151 is a fragment of a jaw of an unknown fish, with large and small teeth; the large tooth is covered with well-defined longitudinal ridges; the small teeth are bright and smooth, and the jaw is covered with elongated tubercular markings. Fig. 152 is the same fragment magnified three diameters. Fig. 153 is a fragment of a jaw, with teeth of nearly uniform size, slender, smooth over a great portion of

their surfaces, and marked with deep infoldings near the bases. The jaw is covered with strongly defined reticulations, which simulate, to some extent, the surface markings on the bones of Carboniferous reptiles. Fig. 154 is a very stout isolated tooth, with a fragment of jaw. The tooth is covered with slight longitudinal inosculating striations, and the jaw is marked with pitted reticulations. Fig. 155 represents, of twice the natural size, a jaw, which in some respects resembles a small mandible of *Megalichthys*, but differs from it by the various sizes of the teeth; the small teeth of *Megalichthys* being of nearly uniform size, while those of the specimen figured differ very greatly both in length and strength. The jaw is more slender than is a mandible of *Megalichthys*, and the markings on the surface more nearly resemble those on *Acrolepis* than on any known Coal-measure fish. Fig 156 is an illustration, three times the natural size, of a fragment of jaw, bearing four teeth of nearly equal sizes. The teeth are broad at the bases, and have a pyramidal appearance, with very sharp apices. The shaft of each tooth is finely striated, and the base of each tooth is deeply plicated. Fig. 157 represents a fragment, three times the natural size, containing six teeth. The characters of the teeth, and the markings on the jaw, much resemble those of fig. 156, and it is not improbable that both specimens belong to fishes of the same genus, the chief difference between them being the thickness of the alveolar ridge of No. 156; fig. 158 is an illustration of a very rare form of denticle, three specimens of which I have obtained, but none of which are attached to jaws. I have considerable doubt respecting their dental character; they may be dermal spines rather than oral appendages. Fig. 159 is a very excellent illustration of a unique tooth from the Northumberland Coal Measures. The tooth is sketched of natural size. The deep longitudinal grooves on the surface of the tooth abruptly terminate within half an inch of the apex of the tooth, and are well represented in the drawing. The only Coal-measure teeth at all resem-

bling this are those of *Rhomboptychius*, but they differ from them in many respects, and as remains of *Rhomboptychius* have not yet been found in Northumberland strata, it may fairly be inferred that the tooth belongs to a new and as yet undescribed genus of fishes. Fig. 160 represents another tooth, of which I have but one specimen. It has the form and the well-defined parallel striations of *Dendrodus*, and, if it belong to that fish, it serves to unite the fauna of the Devonian period with that of the Carboniferous. Figs. 161 and 162 are excellent illustrations, three times the natural size, of a tooth from the Carboniferous Limestone Formation, which a few months ago I named *Anthropodontoides Bailesii*, the generic name indicating its resemblance to the symphysial extremity of a human lower jaw, and the specific name being given in honour of its discoverer, Mr. Bailes. Of this fish, nothing whatever is known, except its teeth, only two of which have been discovered, viz., a specimen which, by the kindness of Mr. Bailes, I forwarded to the British Museum, where it may be seen; and the specimen in my possession, which furnished the illustrations. Fig. 163 is a tooth and fragment of jaw of a new and unnamed Coal-measure fish; fig. 164 is an opercular plate or dermal scale of an unknown fish. It is not improbable that this stout scale belonged to one of the semi-cartilaginous ganoids of the Coal period, and that rows of similar scales flanked the sides of Palæozoic ganoids, as large scales flank the sturgeon, a cartilaginous ganoid of the present day. Fig. 165 is a very rare scale, with a deeply marked and rosette-like surface, genus unknown. Fig. 166 is a side view of a fish vertebra with distinct neural and hæmal processes. Fig. 167 is an ossified bi-concave vertebra, with large notochordal foramen, and is more probably reptilian than ichthyic. The centrum is somewhat more flattened than are those attributed to *Pteroplax*, and is not so deep in the antero-posterior direction as are those that are known to belong to *Pteroplax*. The notochordal foramen is larger than are those of *Pteroplax*, and it

is probable, therefore, that this centrum is one of *Loxomma*, or of some other of the many Labyrinthodonts, remains of which have been discovered in the Northumberland Coal Shale. Figs. 168 and 169 are opercular plates of fishes, of natural size. Other and larger operculæ have been found in the Northern Coal Measures, but to what fishes any of them belong is not yet satisfactorily determined. Fig. 170, two unique bones, natural size. These bones have been seen by several of the chief palæontologists and comparative anatomists in Great Britain, but as yet no clue to their satisfactory interpretation has been received. They bear some resemblance to paired bones of *Archegosaurus*, as illustrated in Von Meyer's "Monograph on German Coal Measure Amphibia." Figs. 171, 172, 173, 174, uninterpreted bones, probably belonging to the heads or shoulder girdles of fishes. Fig. 175 represents a rare and little understood fossil, probably an otolite or ear-bone of a fish; fig. 176, a transparent microscopic section of the same fossil, illuminated by transmitted light, and magnified twenty diameters, showing the minute structure of the preparation. In *Scientific Opinion*, vol. ii., p. 173, after stating that I had five specimens of this fossil, I said, "In external appearance, these specimens closely resemble each other, but, when mounting a specimen a few hours ago, for microscopic examination, I found that, in structure, it very materially differed from that I had previously prepared for the microscope. The first supposed otolite which I mounted was beautifully transparent, of a deep lake colour, and appeared, when examined by objectives of high power, to be perfectly structureless. The present otolite, like that previously described, was very hard and difficult to reduce to a proper degree of thinness. Its structure is marked and peculiar, and its colour is a very deep red. Whatever those bones be, they differ very materially in colour and structure, and probably belong to fishes of different genera, or, at least, of different species. The last specimen, when under microscopic examination, is seen to be exten-

sively permeated or covered by irregular nodular twisted lines, resembling, to some extent, the attached frustules of *Diatoma vulgare*, or the stems and polype cups of the smaller forms of *Sertularia*. To use a familiar illustration, they are not much unlike a number of bent and twisted sticks of barley sugar crossing and intersecting each other in all directions. Among those masses of nodular lines, are scattered a number of small circular discs of various degrees of transparency.

"The fossil remains in the Coal measures are generally somewhat heterogeneously mixed together, and, in some cases, the slabs of shale contain remains that evidently belonged to one fish. When that is the case, somewhat safe inferences may be drawn as to the leading characteristics of the fish, the remains of which have been so preserved. Upon a slab of shale in my possession, there are a large mandibular tooth and various headbones of *Ctenodus*, and associated with them is a very excellent specimen of a supposed otolite. If any inference is to be drawn from this association of fossils, it is that the otolite in question belonged to a *Ctenodus*, and that is not improbable, as, unlike *Gyracanthus*, *Diplodus*, and many other coal-measure fishes, the *Ctenodi* had ossified head-bones, operculæ, and ribs, and, in all probability, were possessed of otolites.

"I have in my possession upwards of 200 upper and lower compound teeth of various species of *Ctenodi*. Two-thirds of the specimens are small, the remaining one-third vary in size from $1\frac{1}{2}$ in. to $3\frac{1}{4}$ in. It is improbable that small bones, such as the otolites of the smaller *Ctenodi*, should be found, and the discovery of the otolites of the larger *Ctenodi* would be much less frequent than the discovery of their teeth, because each fish possessed four, or it may be eight teeth, and would only possess two otolites. Besides, the teeth are large, and easily recognised, and the otolites may easily be overlooked in the process of breaking and examining the shale. The argument of the smallness of the number found

is, therefore, no reason why those found should not belong to the genus *Ctenodus*."

Since the publication of the above remarks in *Scientific Opinion*, Messrs. Hancock and Atthey have published a paper in the "Annals and Magazine of Natural History" and in the "Transactions" of the Tyneside Naturalists' Field Club, in which they attempt to prove that the lenticular bodies which I described as otolites are not otolites, but vegetable fungi, to which they have given the generic name *Archagaricon*, a name which indicates that they resemble hardened fossil mushrooms. Their chief arguments in favour of the vegetable nature of the fossils are the minute structure of some of the specimens, which resemble, to some extent, the structure of certain fungi; and the fact that while fossil bones are easily destroyed in nitric acid, the supposed otolites are not perceptibly affected by the action of the acid. In reference to the fungoid characters of those bodies, Mr. W. Carruthers, of the British Museum, in his review of the contributions to fossil botany published in Britain in 1869 ("Geological Magazine," 1870, p. 182), says: "The authors describe a number of lenticular bodies from the Cramlington Black Shale, which, from their resemblance to *Sclerotium stipitatum* (Berk. and Curr.) they consider to be fungi. These fossil bodies are supposed by Messrs. Hancock and Atthey to be fully developed plants, producing spores, and related to the higher fungi. The authors have overlooked the fact that this 'doubtful' (Berk.) production, which led them to take this view of these bodies, is only a *Mycelium-tuber*, the fructification of which is yet unknown."

In minute structure, these fossils vary, and, as some of them appear to be entirely structureless, structure alone is not sufficient to justify their being considered vegetable remains. With respect to the effect of nitric acid on the fossil, my experience has shown that nitric acid does not visibly affect the forms of the supposed otolites; while it decomposes teeth and other remains of fishes and reptiles, it

nevertheless produces so much of chemical change upon them as to render the previously transparent dilute nitric acid somewhat milky in appearance, indicating the presence of calcareous matter in the otolite. As a further proof of the non-vegetable nature of the supposed otolite, I found, on immersing the specimen in sulphuric acid, no change whatever was produced, and the fluid was not in the least degree discoloured, but, on dropping a cherry stone into the same fluid, active effervescence was at once set up, and the fluid became black as ink. Taking all the facts of the case into consideration, it appears more probable that the fossils are otolites of fishes, rather than hardened fungi.

Fig. 177 is the distal extremity of a spine of an unknown fish. The fragment is $1\frac{1}{4}$ in. long, $\frac{1}{18}$ in. broad at its widest part, and gradually tapers to a needle-like point; along the centre, from base to apex, there is a deep groove, and on each side of the groove is a well-defined semicircular ridge.

Fig. 178 is an interesting illustration of portions of ribs that have been fractured and repaired in the living fish. The phenomenon of remains of ribs repaired in the living fish is not of frequent occurrence, and the specimen figured presents the most marked illustration with which I have met during my researches in the Northumberland Coal Formation.

The preceding chapters place before my readers, in a concise form, some of the leading characteristics of the fishes that inhabited Northumberland estuaries and lakes during the Coal period, and the excellent illustrations by which they are accompanied will enable amateur fossil gatherers in different Carboniferous localities to identify the Coal-measure fossils they discover, or of which they may become possessed. Before a thoroughly satisfactory interpretation of Coal-measure fossils can take place, much investigation yet requires to be prosecuted, and it is earnestly hoped that this preliminary manual may be the means of stimulating colliery owners, mining engineers, overmen, and miners to a more systematic investigation of the fossil remains of their respective localities.

CHAPTER V.

FOOTPRINTS, &c., ON THE LOWER SANDSTONES OF THE CARBONIFEROUS LIMESTONE FORMATION, NORTHUMBERLAND.

ICHNOLOGY, or that department of palæontology which has relation to the interpretation of fossil footprints, is a branch of geological inquiry of very modern date.

The earliest recorded description of footprints in sandstones is that by Dr. Duncan, which first appeared in the eleventh volume of the "Transactions" of the Royal Society of Edinburgh for 1828. The footprints were found in the New Red Sandstone of Scotland, and were inferred by Dr. Duncan to be impressions of the feet of tortoises.

In 1831, Mr. G. Scrope found several small footprints in the layers of Forest marble, near Bath.

In 1834, reports of the discovery of footmarks in the New Red Sandstones of Saxony were published, and, because of the resemblance of the larger tracks to the human hand, they were named *Cheirotherium*, but were subsequently attributed, by Professor Owen, to the now well-known Batrachian, *Labyrinthodon*. Since that time, very indefinite impressions, supposed to be footprints, have been discovered in rocks of Cambrian age, but the greatest variety and number of tracks have been found in the Carboniferous and Permian Sandstones of North America. We are indebted to Dr. Hitchcock and Dr. Deane for a mass of information respecting American Ichnology. Professor Hitchcock's first report was published in the American *Journal of Science and Art* for 1836; his next report appeared in 1841, and subsequently to that time, he has contributed many papers to the elucidation of American and general Ichnology.

Those who desire to become familiar with the history of Ichnology should read Professor Owen's "Palæontology,"

chapter on Ichnology, pp. 176-193; and the American *Journal of Science and Art*, vols. for the years 1836, 1841, 1844.

The footprints, illustrations of which accompany this brief description, were found in the Lower Sandstones of the Carboniferous Limestone Formation, Northumberland. The locality in which they were found is known as Berraker Shields Quarry, Deanhead, near Otterburn, North Tyne. The country in that district is very hilly; indeed, it, for the most part, is uncultivated moorland, and the height of the quarry above the sea level is, according to the Geological Survey, nearly 800 ft. The moor, in which the quarry is situated, is the property of R. B. Sanderson, Esq., ex-Mayor of Newcastle-on-Tyne, and it was from that gentleman I, in the first instance, obtained specimens of the footprints.

The sandstones of which the quarry is composed are of a thin laminated character, varying in thickness from half an inch to two inches. Between each layer of sandstone, there is a thin stratum of soft unctuous clay. In those thin layers of clayey mud, the impressions appear to have been formed, as the vast majority of foot-tracks are raised casts, and not depressions, the impressions having been made in the soft argillaceous material, which is now so friable as to break away and fall to pieces when one layer of sandstone is lifted from the layer beneath. The ex-Mayor of Newcastle has, on two occasions, kindly brought me specimens of footprints from his lofty moorland quarry, and, at his invitation, I, a short time ago, visited the locality. Mr. Lebour, of the Geological Survey, who is at present stationed in the romantic district of North Tyne, obligingly accompanied me on my ichnological rambles. I am indebted to Mr. Lebour for the following stratigraphical information respecting the position of the sandstones which bear the footprints. The following strata lie at or near the base of the Carboniferous Limestone Formation, and the superposition of the strata in descending

order is:—(1.) Long Syke Limestone. (2.) Sandstone with footprints. (3.) Potts Durtrees Limestone. In No. 2, or the sandstone deposit, the footprints about to be described were found.

The Berraker Shields Sandstone Quarry, which is very small, not being more than 30 ft. long, 12 ft. wide, and 2 ft. deep, is, for the most part, worked for the purpose of obtaining flat sandstones with which to build what are locally designated "stells" or roofless circular buildings, about 20 ft. diameter, with walls about 4 ft. high. They are used for the purpose of sheltering sheep during the storms that occasionally prevail in that lofty district. The flat sandstones, because of their flatness, admirably answer the purpose of building rough walls without the necessity of using lime in order to strengthen the buildings that are erected upon the open moors, and the walls themselves afford an excellent field for ichnological research, as the stones, after having been exposed a few months to the weather, have washed from their surfaces the clay on which they were originally embedded, and the footprints, or rather the casts of the footprints, stand upon the stones in bold relief.

The earliest discovery of reptile footprints so low in the Palæozoic rocks as the Carboniferous formation has been assigned to Sir W. E. Logan, who, in 1841, discovered a series of small but well-marked reptile footprints in the Lower Coal Measures of Horton Bluff, Nova Scotia. Since the discovery of the reptile footprints in 1841, other reptile tracks have been discovered, and described by Dr. Harding, Dr. Dawson, Dr. King, Mr. Lea, and others, some of which, especially *Sauropus*, bear a considerable resemblance to the genus figured 181 and 182 in the accompanying sheet of illustrations. It is not uncommon, in works on geology and palæontology, to find the first discovery of reptile footprints in strata as low as the Lower Coal Measures attributed to Dr. King, of Greensburg, Pennsylvania, who discovered the footprints of *Batrachopus primævus* in the year 1844. It

will be seen, by reference to the above dates, that the honour of the first discovery legitimately belongs to Sir W. E. Logan, who, prior to his being knighted, anticipated Dr. King's discovery by a period of three years.

PLATYTHERIUM PSAMMOBATES. *(Nov. Gen.)*

Figs. 179 and 180 illustrate footprints of a quadruped which, on a previous occasion, I named *Platytherium psammobates*, the generic name being indicative of the great width of the animal in proportion to its length, and its specific name having reference to its habitat on sand. The specimens illustrated are types of numerous impressions of a similar character that have come under my observation. In all cases, these footprints run in parallel lines, and every undulation or divergence from the straight track in one line of footmarks is exactly followed by the adjoining. To arrive at any approximately satisfactory opinion as to the class of animal that made the impressions, it is desirable to adopt a selective process among the various hypotheses that present themselves. The theory of a walking bird is superlatively improbable, as the footprints are in pairs, and, generally speaking, are opposite to each other. The theory of a hopping bird is also improbable, as the forms of the foot-tracks, the shortness of the distance between each pair of impressions, the absence of any indication of backward force, and the change in the relative positions of the footprints when the speed has been increased, all indicate the improbability of the marks having been produced by a hopping bird. A hopping or leaping marsupial is also improbable, as more of the feet and some portion of the legs would be visible at each impression. I have heard both crustacean and annelid theories advanced; but these are so thoroughly improbable, that I lay them aside without further consideration. There, then, only remain the hypotheses of their having been produced by amphibians, reptiles, or mammals.

It is not likely that the footprints are those of Batrachia, as they are of uniform size; nor of Chelonia, as there are no indications of body marks; nor that they are Lacertilian, as in the hundreds of impressions I have examined there is not the least indication of marks from either the tail or body of the reptile.

It is not improbable, therefore, that the impressions are those of a small, broad, four-legged mammal, which, probably, was short limbed, and took steps one half the length of the distance between its hind and its fore feet, when in a standing position, and that the hind feet fell into the impressions made by the fore feet during the progress of the animal. Be the facts as they may, the latter appears the most probable hypothesis, as any increase of the number of legs beyond four only increases the difficulty of accounting for the singleness and distinctness of the impressions, and the reduction of the number of feet to two, makes a satisfactory interpretation of the marks still more difficult.

The artist has represented the footprints as tridactyle, but in several impressions there are indications of a rudimentary fourth toe. The index letter *a* marks a compound impression of not unfrequent occurrence in those ichnitic sandstones where the animals walking have lifted and replaced their feet two, three, or more times near the same locality. Slab fig. 179 is about $\frac{1}{2}$ in. thick, and level on the upper surface; slab fig. 180 is about $1\frac{1}{4}$ in. thick, and on the side bearing the casts of the footprints there are distinct indications of ripple marks, *d;* distinct worm, or crustacean tracks, *c;* and a curious and distinct cast of an unknown ammonite-like crustacean, with long tentaculæ, marked *b*. The thin sandstones are, for the most part, free from worm or crustacean tracks and ripple marks, but the thicker slabs, those that average from 1 in. to 2 in. in thickness, are almost invariably marked with distinct ripplings, worm tracks, and crustacean markings.

TRIDACTYLOSAURUS SANDERSONI. *(Nov. Gen.)*

The footprints represented on slabs figs. 181 and 182 are new to Northumberland Carboniferous palæontology, and, I believe, are new to science. They more closely resemble *Batrachopus* and *Sauropus* figured or described in Owen's "Palæontology" and Dawson's "Acadian Geology," than any other ichnites I have seen figured or described. *Sauropus* has four well-defined, and one ill-defined, toes, the impressions of the extremities of which are isolated in the same manner as are those now being described, but the heel marks are very faint, and, in some instances, entirely absent. The impressions of the feet of *Batrachopus* and *Sauropus* are much larger than are those now figured. This new quadruped has been designated *Tridactylosaurus Sandersoni;* the generic name indicating its possession of three toes, and probable saurian affinities, and the specific name being given in honour of R. B. Sanderson, Esq., Mayor of Newcastle-on-Tyne, on whose estate I discovered the impressions, and from whom I received the first discovered slabs of sandstone, bearing the footmarks of *Platytherium psammobates.* Fig. 181 represents a single row of footprints, which, by the angles at which the feet have been placed upon the ground, give the appearance of the walking of a biped; but fig. 182, which bears similar impressions, corrects the inference derived from fig. 181, and points to the conclusion that the impressions have been made by a quadruped, it being improbable that two birds would walk in such close proximity to each other. Further investigations are being made in the Berraker Shields Quarry, and it is not improbable that the question of the two or four footed character of the animals which made these impressions will be established beyond the reach of controversy or doubt.

Chapter VI.

VERTEBRAL COLUMN OF A LARGE LABYRINTHODONT, OR LARGE REPTILE, FROM THE LOW MAIN COAL SHALE, NORTHUMBERLAND.

Carboniferous ichthyology has, by the researches and writings of Professor Agassiz, Sir Philip M. de Grey Egerton, Bart., Dr. John Young, Messrs. Hancock and Atthey, and others, been made more or less familiar to all students of Carboniferous fauna. The remains of Coal-measure fishes, which were accessible to Professor Agassiz when he published his elaborate work on "Recherches sur les Poissons Fossiles," are admirably described and excellently figured by that distinguished naturalist in the work referred to. Since the issue of Professor Agassiz's work, little has been done in Coal-measure ichthyology beyond the publication of brief treatises on isolated specimens, in various scientific journals.

The discovery of some of the remains of the Coal-measure fishes which are now exhibited in our London and provincial museums dates back as far as the close of the last century, but the existence of Labyrinthodonts in strata so low among Palæozoic rocks as the coal measures was not known until 1843, or, at all events, they were not recognised as Labyrinthodonts until that period, as the remains were referred to fishes of the genus *Pygopterus*. Since the elucidation of *Archegosaurus*, in 1843, and its more complete exposition by Hermann von Meyer, in his admirable monograph "Reptilien aus der Steinkohlen Formation in Deutschland," in 1858, much good work has been accomplished among the air breathers of the Coal period.

The existence of true reptiles during the Coal period has not yet been recognised by the leading authorities in coal-measure palæontology, and it is, therefore, on my own authority that I state that a large true reptile, which I have

named *Orthosaurus*, has been found in the Northumberland coal-measure strata. The reasons for believing that the remains are those of a true reptile will be given in a subsequent chapter.

The following genera of large and small coal-measure Labyrinthodonts and Reptiles have been found in Carboniferous strata in England, Scotland, Ireland, and America.

Anthracosaurus, from near Glasgow, described by Professor Huxley; *Loxomma*, from near Edinburgh, by Professor Huxley; *Pholidogaster*, from near Edinburgh, by Professor Huxley; *Pholiderpeton*, from near Bradford, by Professor Huxley; *Eosaurus*, from Nova Scotia, by Professor O. C. Marsh; *Baphetes*, from Nova Scotia, by Professor Owen; *Pteroplax*, from Northumberland, by Messrs. Hancock and Atthey; and *Macrosaurus*, *Amphisaurus*, *Orthosaurus*, *Megalocephalus*, *Labyrinthodontosaurus*, *Amphicœlosaurus*, *Leptognathosaurus*, and *Streptodontosaurus*, all large Labyrinthodonts, or true Reptiles, from Northumberland Coal Shale, by the writer.

Of smaller Labyrinthodonts or Reptiles, the following have been discovered and described, viz., *Hylonomus*, three species from Nova Scotia, by Professor Owen; *Hylerpeton*, from Nova Scotia, by Professor Owen; *Dendrerpeton*, two species, from Nova Scotia, by Professor Owen and Dr. Dawson; *Sauropus*, two species, by Dr. Dawson and others; *Raniceps*, from Ohio, by Professor Wyman; *Amphibamus*, described and figured in the Geological Survey of Illinois, vol. ii., p. 135, pl. 32; *Urocordylus*, *Ophiderpeton*, *Ichthyerpeton*, *Keraterpeton*, *Lepterpeton*, *Dolichosoma*, *Erpetocephalus*, *Discospondylus*, and *Brachyscelis*, from Kilkenny, Ireland, described by Professor Huxley; *Batrachiderpeton*, from Northumberland, described by Messrs. Hancock and Atthey; and *Mesosaurus*, from Northumberland, by the writer.

MACROSAURUS POLYSPONDYLUS. *(Nov. Gen.)*

The specimen of *Macrosaurus polyspondylus*, a figure of which, two-thirds the natural size, accompanies this description, is the only authenticated specimen of the genus that has yet been discovered, and is at the same time the largest and most numerous consecutive series of vertebræ of a Coal-measure Air-breather that has yet been obtained.

The length of the vertebral column is 56 in., and it consists of 80 consecutive vertebræ. Only a few of the cervical, and a very limited number of the caudal vertebræ are present, and the column therefore consists for the greater part of dorsal, lumbar, and sacral vertebræ.

It is not improbable that at least a dozen additional vertebræ were originally attached to the cervical extremity of the column, as the transverse processes for the attachment of the ribs commence on the side of the fourth anterior centrum, and the gradual diminution of the diameters of the vertebræ as they approach the caudal extremity indicate that, as the last vertebra in the specimen has a perpendicular diameter of nearly $1\frac{3}{4}$ in., the vertebræ of the tail must have extended 24 in., or it may be 36 in., beyond the last vertebra of the specimen.

It will be seen, as we proceed, that the heads of the larger Labyrinthodonts of our coal measures were more than 18 in. in length, and it is probable, therefore, that *Macrosaurus*, the vertebræ of which equal in size the largest Coal-measure reptile vertebræ that have been found, had, when entire, a minimum length of 10 ft., and not improbably reached a length of 12 ft.

The vertebræ, as the drawing indicates, are arranged in consecutive order, and gradually diminish in size anteriorly and posteriorly. The diameters of the larger vertebræ are $2\frac{1}{2}$ in., and the diameters of the smaller $1\frac{1}{2}$ in.

The form of each vertebral centrum approaches the

ovoidal, and the longer diameter of each is from the hæmal to the neural side of the column.

The vertebræ, like those of *Anthracosaurus*, *Loxomma*, *Pteroplax*, *Eosaurus*, and the *Mesozoic Enaliosaurians*, are bi-concave. The forms of the centra of *Archegosaurus* are doubtful, they apparently having been entirely cartilaginous, or very slightly ossified, whilst their processes were thoroughly ossified.

The sides of the vertebræ of *Macrosaurus* are also concave, and are rather longer in the hæmal than in the neural aspect. A, E, is the anterior extremity, and P, E, the posterior extremity; the other ends of the drawing, indicated by arrows, are in contact in the specimen, and the figure is merely divided to economise space. The fossil in my possession consists of nine pieces, which join together at the positions indicated by the transverse lines on the drawing.

The ribs *a*, *a*, *a*, which are strong and nearly circular, are well ossified, and differ from the reputed ribs of *Anthracosaurus* in form, strength, and minute structure. Illustrations of transverse and longitudinal sections of ribs of both genera are given in a subsequent chapter. The transverse processes for the articulation of the ribs are in the dorsal region very well defined; they present the appearance of flat, oval elevations, and are represented on the superior portions of the dorsal vertebræ by oval spaces indicated by *e*, *e*, *e*. In addition to the transverse processes, there are also strong, flat, neural spines, but in or at the bases of those neural spines I am unable to detect any traces of a neural canal; this may arise from the fact of the processes having been partly cartilaginous, and the neural canal may have been obliterated by the pressure of the matrix. Towards the lumbar extremity of the specimen, there are several small slender free ribs, indicated by *b*, the proximal ends of which are expanded and concave, and appear to have articulated on processes that somewhat resemble in form the chevron bones in fishes. The only fragment of either anterior or posterior limbs is a very

imperfect bone, marked *d*, which is not improbably a humerus, or it may be one of the elements of a shoulder girdle.

The wing-like expansions, marked *c*, *c*, are thin and cartilaginous, and may either be fin-like extensions, on the dorsal side, near the anterior extremity of the tail, or they may be the remains of a series of semi-cartilaginous fins, which extended along the upper surface of the body, in a manner resembling those on the dorsal ridge of the modern *Basiliscus mitratus*.

The only tooth found associated with this large specimen is a single, flattened, lanceolate tooth, resembling those ascribed to *Pteroplax cornuta*, but it is impossible to say whether it did or did not belong to *Macrosaurus*, and the teeth of *Macrosaurus*, therefore, are unfortunately unknown. If our Northumberland Saurians had dermal scutes, it is very remarkable that up to the present time scutes of Coal-measure Labyrinthodonts or Reptiles have not been found in Northumberland Coal Shale, and the inference is rather in favour of their having been scuteless, than of their having had scutes and that none have up to the present time been discovered. The non-discovery of dermal armour is the less surprising when we reflect that with *Ichthyosauria*, *Plesiosauria*, *Dicynodontia*, and *Pterosauria*, all of which are true reptiles, no exoskeleton has yet been discovered, and it may have been that our Coal-measure free-swimming reptilians, like their Mesozoic successors, were without exoskeletal coverings. In size, dentition, and forms of vertebral centra, there are strong resemblances, and it is not improbable that the resemblance also extended to the absence of bony or horny armour.

CHAPTER VII.

CRANIA AND MANDIBLES OF COAL-MEASURE REPTILES AND LABYRINTHODONTS.

AMONG the reptile crania and jaws discovered in the Northumberland Low Main coal shales, those the illustrations of which accompany this chapter rank with the most perfect and most remarkable.

The greater portion of the reptile remains from our northern coal fields that have come into my possession are fragmentary, and the only perfect, or approximately perfect, cranium that I have obtained is that which is represented, of natural size, by figs. 183, 184, and 185, which I have designated *Orthosaurus pachycephalus.*

ORTHOSAURUS PACHYCEPHALUS. *(Nov. Gen.)*

The specimen lies in a matrix of ordinary black shale. The inner or palatal surface, which is presented in fig. 183, is that which is exposed in the specimen, and the upper surface, with the exception of the premaxillary extremity marked A, and the posterior extremities marked B, B, is covered with a thick coating of shale. Not only is the inner aspect well exposed, but the whole of the premaxilla and the anterior portion of the nasal bone are free from the matrix, and are beautifully exhibited on the upper or surface aspect. The dotted lines at the anterior and posterior extremities of the specimen represent fractures, and the fig. 185 is an excellent illustration of the upper surface of the premaxillary and a portion of the nasal bones. The fractured portions indicated by the anterior dotted lines marking off the parts of the fossil B, B, are also free from, and may be lifted off the matrix, and when so lifted, placed together, and reversed, they present those portions of the upper surface of the cranium that are

embraced in the parietal, squamosal, post-frontal, frontal, and portions of the pre-frontal and jugal bones, as depicted in fig. 184.

The fossil cranium on which this new genus has been founded is $15\frac{1}{2}$ in. long, and $8\frac{1}{2}$ in. broad at the posterior or quadrate extremity: it gradually diminishes in width towards the anterior end, and is terminated by a graceful rounding of the premaxillary bones. In general form and configuration, in the position of the orbits, in the absence of a parietal foramen, in the strength of the quadrate bones, in the freedom of the palate and vomer from dentition, and in the form of the premaxillary bones, the cranium of *Orthosaurus* very closely resembles that of a modern Crocodile. The sutures of the bones in any part of the cranium are undistinguishable, and the nasal orifices, if near the extremity of the snout, are small and difficult to determine.

The teeth are circular in section, and, with the exception of those in the premaxilla, are of different sizes, and placed at various distances from each other. In the premaxilla, there are eight teeth, which are placed at nearly uniform distances from each other, and all of which are fractured transversely, and are, as already stated, circular in transverse section.

On the left side of the specimen, as indicated in the illustration, and near the anterior transverse fracture, there is a large tusk-like tooth, which, at a distance of 1 in. from the base, has a diameter of $\frac{5}{16}$ in., and which must, when perfect, have been $1\frac{3}{4}$ in. long. Between it and the next large tooth, there are three small teeth, also circular in section and about $\frac{1}{2}$ in. long. At a distance of $2\frac{1}{2}$ in. from the first large tooth is another tooth rather less in diameter, and upon it is fixed a concave reptile vertebra *e*, $1\frac{3}{4}$ in. in diameter and $\frac{3}{8}$ in. thick, through the notochord of which, as represented by the drawing, a tooth has been pressed, and upon which the vertebra is firmly fixed. At $2\frac{1}{2}$ in. from the tooth which bears the vertebra, is another broken tooth, which, when whole, must have been $1\frac{1}{4}$ in. long, and it is followed by three well-defined

small teeth and indistinct indications of others. On the right side, large teeth, such as those described on the left side, are absent, and no indications of their having been present are visible, but opposite the last large tooth, on the left side, there is a large tooth on the right side which equals in size the largest tooth belonging to the opposite side of the cranium. Small teeth at irregular intervals precede and follow the large tooth just described. The whole of these teeth are upon, or in close contiguity to, the alveolar border, and, with the exception of the first tooth on the left side, all appear to have been pressed in the matrix from left to right. All the teeth, along the greater part of their length, are marked with well defined semicircular ridges, the grooves being deep and sharp, and the intervening ridges being distinctly semicircular.

The markings on the external surface of this fine cranium bear a general resemblance to the surface markings on the cranial bones of other large Labyrinthodonts or Reptiles of the Coal period. The rugose surface markings differ from those usually ascribed to *Loxomma* by being finer and more delicate; the pittings are, for the most part, nearly circular depressions, they do not coalesce with sufficient frequency to resemble the deep confluent grooves that characterise *Loxomma* and other large Labyrinthodont remains from the Northumberland Coal Measures. The surface markings differ, as has been said, from those on the reputed bones of *Loxomma* by being much smaller and more regular; they resemble those that are on the reputed cranial shield of *Anthracosaurus* now in my possession, and figured 187; they are greatly more delicate than are those on the head of a new reptile which I propose to describe and figure in the next chapter, and which I have named *Megalocephalus macromma*; they are more coarse than are the markings on the bones of *Labyrinthodontosaurus*. The markings on the reputed jaws of *Pteroplax*, although more confluent, resemble those of *Orthosaurus*, and the head bones of the only other large reptiles from the Northumberland Coal Measures, viz., *Macrosaurus*, *Amphi-*

saurus, *Leptognathosaurus*, *Streptodontosaurus*, and *Amphicœlosaurus* are, as yet, unknown.

The quadrate extremities (Q) of *Orthosaurus* differ from those of the Labyrinthodonts before named, the heads of which are known. In nearly all the Labyrinthodonts, except *Pteroplax*, there are distinct and large expansions in the temporal regions, expansions which are totally absent from the reptile now described, and as manifestly present in *Anthracosaurus*, *Loxomma*, and many others.

The epiotic bones of *Orthosaurus* differ from those of *Archegosaurus*, *Pteroplax*, *Pholidogaster*, and other Labyrinthodonts, in the entire absence of the long posterior cornua that characterise those and probably all other mere Labyrinthodonts. The parietal bones of *Orthosaurus* also differ from those of all known Coal-measure Labyrinthodonts in the absence of a parietal foramen, which is possessed by *Archegosaurus*, *Loxomma*, and *Pteroplax*.

The thickness of the skull of *Orthosaurus* between the inner and outer surfaces, in the region of the post-frontal and parietal bones, is 1 in., and, as the fossil has been fractured longitudinally through the centres of these bones, a cavity filled with a black shaley matrix is revealed, which, there is much reason for believing, is the comparatively small brain cavity which belonged to this huge reptile of the Palæozoic era. The brain cavity, as well as can be determined, is 2 in. long and $\frac{1}{2}$ in. deep.

The shapes of the apices of the tusk-like teeth of *Orthosaurus* cannot be positively determined, as all the tusks are broken transversely at about one-half of their length; this much, however, may be inferred—that, as all the shafts of both large and small teeth are perfectly circular, it is rather improbable that any of them had the distinct lanceolate form near the apices which is characteristic of the reputed *Pteroplax* teeth and of those of *Loxomma*, and that they were, like *Amphisaurus*, *Leptognathosaurus*, and *Labyrinthodontosaurus*, circular from base to apex. A sub-

sequent careful examination of the more perfect small teeth in the cranium leads me to think that near the apices the small teeth are very slightly lanceolate, but within a short distance of the apices the sections are, to all appearance, quite circular.

Found at the same time, and closely associated with the head of *Orthosaurus*, was a considerable portion of a right mandible, the symphysial and articular portions of which are both wanting, and the large fragment in my possession is the middle of a right mandibular ramus. The specimen is 8 in. long, $2\frac{1}{2}$ in. deep at its widest part, $1\frac{1}{2}$ in. deep at the anterior extremity, and $2\frac{1}{4}$ in. deep at the posterior extremity.

The mandible is covered with rugose markings, but the markings are most faint near the alveolar edge. The greatest thickness of the jaw is $\frac{9}{16}$ in. There are the remains of but three teeth visible, all of which are fractured close to the base, and the basal sections are oval, but whether the ovoid form be natural or the result of pressure cannot easily be determined. The teeth are marked with semi-columnar ridges, very closely resembling those on the teeth of *Orthosaurus*, and, with the exception of the teeth of *Streptodontosaurus*, are unlike the markings on the teeth of any other Coal-measure Reptile or Labyrinthodont with which I am acquainted; so that, taking into account the size of the jaw, the character of the surface markings, the striation and ridging of the teeth, and the fact that this jaw and the cranium of *Orthosaurus* were found about the same time, and in the shale of the same colliery, it is not altogether improbable that the cranium and mandible belonged to one animal.

ANTHRACOSAURUS RUSSELLI. (*Huxley.*)

Fig. 186 is a fac-simile of a sketch of a cranium of *Anthracosaurus* of one-third the natural size, copied from a woodcut illustration of the head of that Coal-measure

Labyrinthodont which accompanies an elaborate description of it by Professor Huxley in the *Quarterly Journal of the Geological Society*, vol. xix. The sketch has been introduced to show the contrast between the head of *Anthracosaurus* and that of *Orthosaurus*, and the most casual examination will exhibit the marked differences between these two large crania. It will be seen at a glance that the muzzle of the former is narrow, while that of the latter is broad; the teeth of *Anthracosaurus*, like those of all known Labyrinthodonts, are not confined to the alveolar border of the jaw, but are placed upon both vomer and palate, while the entire absence of both vomerine and palatal teeth from the head of *Orthosaurus* separates it at once from any known Labyrinthodonts, and elevates it into the class of true Reptilia. According to Professor Huxley, the portions indicated by *a*, *b*, *c*, *d*, *e*, and *f* are—*a*, anterior palatine foramen; *b*, posterior nares; *c*, supratemporal foramen; *d*, place of attachment of left vomerine tusk; *e*, vomerine tooth; *f*, palatine tooth and alveolar plate.

Fig. 187 is an excellent illustration of a considerable portion of a cranial shield of a Coal-measure Reptile, from the Northumberland Coal Strata. In the "Transactions" of the Tyneside Naturalists' Field Club, this fossil has been described as the central portion of a cranium of *Anthracosaurus*. Any interpretation then put upon the specimen is, to a great extent, unreliable, as, up to the time of the description of those cranial bones, the upper aspect of the cranium of *Anthracosaurus* had not been determined, and, even now, it is an open question whether any of the remains since discovered in the Northumberland Coal-measures, and ascribed to *Anthracosaurus*, do not belong to some other large Coal-measure Labyrinthodont. Carboniferous reptilian palæontology is in that stage when positive assertions are, in the highest degree, unbecoming, as the means of determining with rigid accuracy the majority of the genera of Coal-measure Labyrinthodonts are not yet in the possession of any palæontologist, and the

conclusions that can yet be arrived at must, as a matter of necessity, be tentative and provisional. The width of the frontal bones, and the peculiar surface markings on the specimen, are not sufficient to justify its being attributed to *Anthracosaurus*, and the broad wing-like expansions (*c*) which flank the pre-frontal and nasal bones (*b*) indicate that the specimen belonged to a cranium much broader in the anterior extremity than that of *Anthracosaurus* is known to be. I propose to recognise this cranial bone as belonging to an unknown reptile. The total length of the specimen is 8 in.; its greatest width at the anterior extremity is $2\frac{3}{4}$ in.; near the posterior extremity, 3 in., and from orbit to orbit (*a*), $1\frac{5}{8}$ in.

The surface markings, to some extent, resemble those of *Orthosaurus*, and, comparing fig. 187 with fig. 184, the dissimilarity between the two crania is not great, and might easily be accounted for by various degrees and directions of pressure, when the matrices were soft and pliable.

Fig. 188 represents a right mandible, probably of a Labyrinthodont. The specimen is $13\frac{1}{2}$ in. long, and is perfect at both the symphysial (*a*) and articular extremities (*b*). The cavity for the articulation of the quadrate bone is small for a mandible of the length described. The teeth are of two sizes, large and small, and they are placed on the alveolar border of the jaw at irregular intervals. Near the symphysial extremity, there is a very large tooth, which is preceded by a very small one, and followed, as the drawing indicates, by two small, two large, a small and large, a small and large, and finally, two small teeth. The whole of these teeth are deeply grooved to near the apices. They are nearly circular in their basal sections, but present a distinct lanceolate appearance towards the apices. The teeth they most nearly resemble are those of the reputed *Pteroplax*, but the ridges and the grooves on their surfaces are larger than those on the reputed teeth of *Pteroplax*, and the teeth are rounder and less lanceolate than are those ascribed to that Labyrinthodont. Nearly all the teeth are more or less broken, and the middle large tooth is

bent backward. The pittings on the surface of this jaw are more confluent than are those of any of the specimens previously described, and are more bold than are those on a supposititious jaw of *Pteroplax* in my possession. I prefer, therefore, to recognise the mandible as new and unknown.

Notwithstanding the unflagging industry with which the Northumberland and Staffordshire Coal Measures have been searched by local investigators, this mandible is the only specimen of the genus, perfect or imperfect, that up to the present time has come under my observation. This fact, though interesting, is not specially remarkable, because only one specimen each of the two genera, *Leptognathosaurus* and *Streptodontosaurus*, have been found, and in both instances they were perfect mandibles. Some Labyrinthodonts and Reptiles appear to have been tolerably abundant during the Carboniferous period, others have been extremely rare, and in almost all cases it is the mandibles of the rare genera that have been discovered, and on which the new genera have been founded.

Chapter VIII.

CRANIA, MANDIBLES, VERTEBRÆ, RIBS, SCAPULÆ, AND LIMB BONES, OF COAL-MEASURE LABYRINTHODONTS AND REPTILES, AND JAW OF SUPPOSED COAL-MEASURE MAMMAL.

In the present chapter, I propose to describe and illustrate a series of typical Amphibian and Reptilian remains from the Northumberland Low Main Coal Shale, the majority of which have not previously been figured, some of which have not before been described, and the descriptions of the remainder which have appeared have been scattered through various scientific periodicals. The remains which are figured are of a very miscellaneous kind; they embrace at least seven known and recently described genera, and several fragments of unknown Amphibia and Reptilia.

The first, and most conspicuous, in the series is that represented by fig. 189; it is the greater part of a cranial shield of a new genus of Coal-measure reptile, which I have named, in accordance with the magnitude of the head and the enormous size of the eyes, *Megalocephalus macromma*, and of which, prior to the present description, there has not appeared any published account.

MEGALOCEPHALUS MACROMMA. (*Nov. Gen.*)

The cranium on which this new genus is based differs very considerably, in many respects, from all the heads of Coal-measure Labyrinthodonts or Reptiles that have yet been described or figured. Taking the dimensions of the right or perfect side of the specimen as a means of determining the entire width of the cranium, it must, when complete, have had a transverse diameter of 11 in., about 1 in. behind its

enormous orbits, measuring from the posterior extremities of the jugal or malar bones on each side. As the length of the cranial fragment in my possession is 8 in., its total length, allowing for the restoration of the nasal and premaxillary extremities, must, at the lowest computation, have been 16 in.

The cranial bones present in the specimen are the frontal and a portion of the pre-frontal bones occupying the space between the orbits, the post-frontal bones attached posteriorly to the frontal, and forming the posterior boundaries of the orbits, the parietal bones behind the frontal and post-frontal forming the posterior central extremity *d*; the mastoid of Professor Owen or squamosal of Professor Huxley, at each side of the parietal, the greater portion of that on the left side being absent; on the right side, the quadrate bone of Huxley corresponding with the squamosal and probably lachrymal bones of Owen. On each side of the cranium forming the outer boundaries of the orbits, are the malar or jugal bones, that on the right being in the natural position and of the normal form, while that on the left has been broken and crushed within the area of the orbit. The whole of the bones forming the external aspect of the skull are covered with deep rugose markings, the pittings being well defined and of various sizes, and occasionally inosculating, so as to form interrupted furrows. Within the areas of the orbits marked *a*, *a*, at the base of the deep depression between the quadrate and mastoid bones marked *b*, known in crocodiles as the temporal fossæ, and extending an inch beyond the right-hand posterior extremity of the pitted cranial bones, there are bones with smooth surfaces having a semi-gloss.

The smooth floors of the orbits appear to be formed by the inner side of the palatal and, it may be, a portion of the pterygoid bones pressed up against the orifices, and the smooth bone, forming the floor of the fossa, *b*, may have been forced up in a similar manner. The smooth flat bone, extending posteriorly to the quadrate, has probably been for the attachment of the strong muscles which would be required to

move the head of a creature so strong and formidable as that to which this huge cranium belonged.

Between the post-frontal and the malar or jugal bones, there is a strong commissural osseous ridge, which forms the postero-lateral boundary of the orbit, and materially strengthens that portion of the cranium by forming a projecting superciliary ridge.

The width of the frontal bone at the anterior extremity is $1\frac{3}{4}$ in., and its thickness is $\frac{3}{8}$ in. The thickness of the cranium at the posterior fractured extremity *d* is $\frac{3}{4}$ in., and, measuring from the centre of the parietal bones, the width of the parietal, mastoid, and quadrate bones is $5\frac{1}{2}$ in.

This cranium differs from that of *Loxomma* (fig. 190) in many manifest particulars. The orbits are parallel with, instead of being oblique to, the frontal bone; the quadrate extremities of *Loxomma* are greatly expanded, while those of *Megalocephalus* diminish in width posteriorly; the head of *Loxomma* is long and narrow, while that of *Megalocephalus* is short and broad. *Loxomma* possesses a distinct temporal foramen which is absent in *Megalocephalus*. *Megalocephalus* also differs from *Pteroplax* (fig. 191) to so great an extent that detailed comparison or contrast is unnecessary. It differs from *Orthosaurus*, as may be seen by referring to the description in a previous chapter and to fig. 184; it has but little resemblance to *Anthracosaurus* (fig. 186); it is greatly unlike the reputed *Anthracosaurus* (fig. 187); it does not bear any resemblance to the head of *Archegosaurus* (see Owen's "Palæontology," p. 194), to *Baphetes* (see Dawson's "Acadian Geology," p. 328), nor to *Pholidogaster* (*Journal of the Geological Society*, vol. xviii., p. 296). The forms of the crania of *Amphisaurus*, *Labyrinthodontosaurus*, *Leptognathosaurus*, *Streptodontosaurus* and *Amphicœlosaurus* are quite unknown, and, as there are not any other large Reptiles or Labyrinthodonts from the Northumberland Coal Measures, the erection of this into a new genus is not permissible merely, but is, in the interests of science, imperative.

AMPHISAURUS AMBLYODUS. *(Nov. Gen.)*

This genus of Coal-measure reptiles was founded upon two fragments of the same jaw discovered in the Northumberland Coal Shales, and was originally described in *Scientific Opinion*, vol. iii., p. 95. On one fragment, there are five well defined teeth and a large portion of the dentary bone, as illustrated in fig. 192; and on the other fragment there are three teeth and the distinct impression of a fourth. The length of the larger jaw fragment is 4 in., its depth is 1 in., and its thickness is $\frac{3}{8}$ in. The teeth are each of nearly uniform length, viz., $\frac{9}{16}$ in.; they rise almost perpendicularly from the alveolar border of the jaw, and, like ordinary columns, are of nearly uniform diameter to near the apices. The teeth in the illustration taper much too rapidly towards the apices. The apex of each tooth is turned off at an obtuse angle, and the apices themselves are exceedingly blunt. The teeth are circular in form, and have not the slightest tendency to the lanceolate form which is said to be characteristic of *Anthracosaurus*, and which certainly is characteristic of *Loxomma*, *Streptodontosaurus*, and some other Coal-measure Labyrinthodonts. The teeth, as the drawing indicates, are placed at irregular intervals, are marked by distinct longitudinal striæ, and are strongly plicated at the bases. The only other specimens of the reptile with which I am acquainted are one in the possession of Mr. Ward, of Longton, Staffordshire, and one in the cabinet of Mr. Simm, of West Cramlington, Northumberland. Coloured magnified sections of the teeth of *Amphisaurus*, and of several other Reptiles and Labyrinthodonts, are given in the accompanying illustrations, and palæontologists have an opportunity of examining the beautiful diversity of forms they present, and will recognise the value of sections in enabling investigators to discriminate between genera of Labyrinthodonts and Reptiles which, so far as the external appearances

of the teeth are concerned, have much in common and present many interpretive difficulties.

ANTHRACOSAURUS RUSSELLI. (*Huxley.*)

Fig. 193 is an illustration, natural size, of the posterior or articular extremity of a large left mandible of a Coal-measure reptile which not improbably belongs to *Anthracosaurus;* but as a mandible of *Anthracosaurus* was not found associated with the cranium on which the genus was founded, and as mandibles and crania have not since been found associated, all inferences respecting this huge mandible can only be provisional and approximate. This is more especially the case when we know that several Labyrinthodonts and Reptiles equal to and exceeding in size any known specimen of *Anthracosaurus* have been discovered in the Northumberland Coal strata, and that, up to the present moment, undoubted and indisputable specimens of *Anthracosaurus* have not been found in our Northern Coal Fields. Specimens that, to some extent, resemble *Anthracosaurus*, as described by Professor Huxley in the *Journal of the Geological Society of London*, vol. xix., p. 56, have been discovered and described, but the differences in the dentition are sufficiently great to justify any one in refusing to accept as final the statement that our local supposed specimens of *Anthracosaurus* are identical with the *Anthracosaurus* of Professor Huxley.

The specimen in my possession consists of four fragments which, when placed together, have a total length of 16 in.; but it is quite manifest, from the depth and strength of the jaw and the forms of the fragments, that a considerable portion of the mandible has been lost, and that its entire length could not have been less than 20 in., and was, probably, considerably more. The diameter of the articular cavity, *a*, is 1 in., and the depth of the cavity is $\frac{1}{2}$ in. The depth of the jaw, within $2\frac{1}{2}$ in. of the posterior extremity, is 3 in., and the thickness of the jaw, in the region of the articular cavity, is

1½ in. The jaw, while so thick, deep, and strong at the articular end, is remarkably reduced near the symphysial extremity. Within 2 in. of the point of symphysis, it is only 1 in. deep, and near the symphysial point it is ⅞ in. thick. The teeth that are visible along the alveolar border are seventeen in number, but, as some portions of the border are yet covered by the matrix, it may fairly be inferred that other teeth are there, but invisible. The teeth are comparatively small for the enormous size of the jaw, the largest not exceeding 1 in. in length and the smallest being ¾ in. long. They are placed at irregular intervals from each other, and in some cases they are placed in close contact. The teeth are broad at the bases, and taper somewhat rapidly to the apices, which are rather blunt, somewhat curved, and slightly lanceolate. The teeth are marked by distinct but delicate longitudinal striæ placed widely apart. The striæ cover about three-fourths the length of the teeth from the bases towards the apices, and at the apices the surfaces of the teeth are covered with slight inosculating ridges that resemble, in appearance, the surface markings on the teeth of *Acrolepis*, *Pygopterus*, and other tipped fish teeth of the Coal period.

The surface of the mandible is marked with the pittings and ridgings that are so characteristic of Coal-measure Labyrinthodonts and Reptiles, but the pittings are more confluent than are those on the jaws and head bones of other Reptiles and Labyrinthodonts, and present more the appearance of waving furrows than of isolated pittings.

In *Scientific Opinion*, vol. ii., p. 235, I referred to the probable occurrence of *Anthracosaurus* and *Loxomma* in the Northumberland Coal Measures; yet, notwithstanding the additional researches of industrious local palæontologists, the existence of the remains of *Anthracosaurus* in this locality still remains a probability. Along with this huge mandible, several vertebræ were found, one of which is represented by fig. 201. The original description of *Anthracosaurus* is contained in the *Quarterly Journal of the Geological Society*,

vol. xix., and fig. 196 of the present series of illustrations is a fac-simile of the illustration accompanying that description. Fig. 190 is copied from the figure of *Loxomma*, in Professor Huxley's paper on that Labyrinthodont contained in the same journal, vol. xviii., p. 291.

Since the foregoing was written I have obtained a large fragment of a splendid right mandible, which possibly belongs to *Anthracosaurus;* the length of the fragment, which is probably little more than half of the mandible, is 13 in., and its greatest depth is $3\frac{1}{2}$ in. Several teeth of nearly uniform size are attached to the jaw, and near the alveolar border there is a huge vertebra, the centrum of which has a very small notochordal foramen. The height of the centrum is $1\frac{3}{4}$ in., the width is $1\frac{11}{16}$ in.; the length, in the antero-posterior direction, is $\frac{7}{8}$ in. The ends of the centrum are deeply concave, the sides are also concave, and there are not any traces of either neural or transverse processes. The centrum closely resembles several in my possession, and if the mandible be one of *Anthracosaurus*, it is almost certain that the centra of that Labyrinthodont are now clearly identified.

LABYRINTHODONTOSAURUS SIMMI. (*Nov. Gen.*)

The fragment of a jaw which is represented by fig. 194 is new to science, and has only previously been described in the *English Mechanic* for May 19, 1871, p. 207, where an excellent figure of a transverse section of the base of a tooth is given.

The jaw, which is a mandible, is remarkably well exposed, the average depth being $1\frac{3}{8}$ in., and the average thickness about $\frac{5}{8}$ in.

The external surface of the jaw is covered with distinct tubercular markings and delicate dendritic grooves. The delicacy of the markings on the jaw would, without other evidence, render the interpretation of the fossil somewhat

doubtful, but the structure of the teeth and the characters of the accompanying head bones confirm the reptilian nature of the fossil. The fish remains which these most nearly resemble in external appearance are those of *Strepsodus*, and some eminent palæontologists even now ascribe the remains to that little understood fish.

The jaw in my possession contains eighteen teeth, four of which have an average length of $1\frac{1}{4}$ in., ten of which average $\frac{1}{2}$ in. in length, and the remainder are smaller. The teeth, as the sketch indicates, are slender and gracefully curved; they are nearly smooth on the convex side, and are marked with very distinct longitudinal parallel grooves and ridges on the concave side. Both large and small teeth are circular, and there is no indication of a tendency to the lanceolate form which characterises many of the Labyrinthodont teeth.

The teeth, unlike those of the *Labyrinthodontia* and lower reptiles, are not anchylosed to the jaw, nor are they inserted in long alveolar grooves, but, like the Crocodilia and higher Reptilia, they are inserted in deep independent sockets, to the depth of at least $\frac{3}{8}$ in., and portions of the jaw into which the teeth are inserted sink into the deep depressions which surround the teeth at their bases. In the penetration of the jaw into the longitudinal sulci of the teeth, and in the forms of the convolutions of the dentine, the teeth resemble, to a considerable extent, those of *Ichthyosaurus*, as figured in Professor Owen's "Odontography," pl. 64 B, fig. 3. The teeth, so far as I am aware, are unique in this respect, that the enamel which invests the summit of each external dental ridge thins off, as it approaches the sulci or depressions, and does not enter to the least extent into the grooves on the surface of the teeth. The pulp radiations and external depressions occur alternately, and the prolongations from the pulp cavity slightly enter the base of each superficial ridge. Enlarged figures of these and other reptile teeth are given in the sheet of coloured illustrations, plate 10.

PTEROPLAX CORNUTA. (*Hancock and Atthey.*)

This is an anterior extremity of a reputed right mandible of a Coal-measure Labyrinthodont of large size, which was described by Messrs. Hancock and Atthey in the "Annals of Natural History," and in the "Transactions" of the Tyneside Naturalists' Field Club, vol. iii., new series, p. 62, and named by them *Pteroplax cornuta*. The chief characteristics of this Labyrinthodont are its supposed possession of flattened lanceolate teeth, somewhat resembling those of *Rhizodus lanceiformis*, and of long cornua, or horns, on the epiotic extremity of the cranial shield, as represented by *e*, *e*, fig. 191. The correctness of the original description of this Labyrinthodont is more than doubtful, as the writers have themselves acknowledged an error into which they stumbled in the interpretation of the cranial shield, and recent discoveries have rendered it more than probable that their inferences respecting the jaws, teeth, and vertebræ, which they allotted to *Pteroplax*, are entirely without foundation.

BATRACHIDERPETON LINEATUM. (*Hancock and Atthey.*)

Fig. 196 represents the left mandible of a very rare and small reptile, found in the Northumberland Coal Measures. Specimens of this reptile are exceedingly rare, there being known but three or four, viz., a few in the cabinet of Mr. Thomas Atthey, Gosforth, Northumberland, and that now figured. This scarce and frog-like reptile has been ably described and excellently figured by Messrs. Hancock and Atthey, in the "Transactions" of the Tyneside Naturalists' Field Club, vol. iv., pt. 1, p. 209.

REPTILE RIBS.

Figs. 197 and 198 represent ribs of reptiles found in our Northern Coal Measures, but to which of the known Coal-measure Reptiles or Labyrinthodonts they ought to be allotted

it is impossible, with our present knowledge, to determine, as the only ribs that have been found distinctly and unmistakeably associated with vertebræ are those of *Macrosaurus*, already described and figured.

The ribs of *Macrosaurus* are nearly circular, and those represented by figs. 197 and 198 are much flattened. The rib, fig. 197, is perfect; the tuberculum, *a*, and the capitulum, *b*, are both well displayed. The distal extremity of the rib is much flattened, as though for some cartilaginous attachment. The capitulum and tuberculum of the fragment, fig. 198, are much more pronounced and distinct, and both ribs, at their proximal extremities and in their general form, bear considerable resemblance to the supposed rib of *Anthracosaurus* described by Professor Huxley, and figured on page 63, vol. xix., of the "Journal of the Geological Society of London."

REPTILE VERTEBRÆ.

Fig. 199 is an illustration of a large form of flattened, discoidal vertebræ, with large notochordal foramina, that are found not unfrequently in the coal shale associated with the Northumberland Low Main Coal seam. The specimen figured represents one of the largest size that has been found. It is, as the figure indicates, very nearly circular; its larger diameter being $2\frac{3}{16}$ in., and its shorter diameter, $2\frac{1}{16}$ in. It is of nearly uniform thickness in the antero-posterior direction, the average thickness being $\frac{5}{16}$ of an inch. The large central notochordal foramen, *b*, is $\frac{7}{16}$ in. in diameter, and is very nearly circular. The edges of the foramen are rounded; the circumferential edge of the centrum, *a*, is concavo-convex, the outer margin being convex and the centre being concave. Deep radiating striæ, extending from the notochordal foramen to the circumference, mark each side of the vertebra. The surface of the vertebra has a rough semi-cartilaginous appearance. The majority of reptile vertebræ found in the Northumberland Coal shale are much better ossified than are

those which resemble that now being described, as may be seen by reference to figs. 200 to 203, the first of which appears to have been a caudal vertebra, and has a solid centrum, and the latter have each a very small notochordal foramen, *b*. In *Archegosaurus*, the first discovered and described Coal-measure Labyrinthodont, the centra were little, if at all ossified, but the neural, hæmal, and transverse processes were ossified. As the centra of *Archegosaurus* were little more than cartilaginous, it is not improbable that some of our large Northumberland Coal-measure Labyrinthodonts may also have had very partially ossified vertebræ; and it is probable, therefore, that the centrum, *a*, No. 199, belonged not to a fish, which, so far as we know, had but slight ring-like centra (see *Rhizodopsis*, fig. 69; *Megalichthys*, fig. 82; and *Strepsodus*, fig. 119), but to one of our largest Coal-measure Labyrinthodonts. It is quite impossible to say to what Amphibian the vertebra figured belonged, but certainly not to *Macrosaurus*, the centra of which were solid, as represented by fig. 182, pl. vii.; probably not to *Anthracosaurus*, certainly not to *Pteroplax*, supposititious vertebræ of which are represented by figs. 201 and 202. Whether they belonged to *Amphisaurus*, *Orthosaurus*, *Labyrinthodontosaurus*, *Megalocephalus*, or *Loxomma*, the fragmentary character of our knowledge of these genera renders it quite impossible to determine.

Fig. 200 is a very excellent illustration of a small solid centrum, belonging, probably, to the caudal extremity of some of the known Labyrinthodonts or Reptiles. The centrum has an ovoidal form, the longer diameter being $\frac{13}{16}$ in. and the shorter $\frac{11}{16}$ in. The length of the vertebra in its antero-posterior direction is $\frac{7}{16}$ in., and both the anterior and posterior extremities are deeply concave. There is not any indication of a notochordal foramen, and only the faintest trace of a neural process.

Fig. 201 illustrates a typical form of a highly ossified and differentiated reptile vertebra, approximately perfect speci-

mens of which are exceedingly rare in our Northumberland Coal Shale. It resembles, to a slight extent, the vertebra figured and described in the "Transactions" of the Tyneside Naturalists' Field Club, and ascribed to *Pteroplax*, a copy of the illustration of which, three-fourths the natural size, is given by fig. 202. The following are the dimensions of vertebra No. 201: height of centrum, *a*, 2 in.; transverse diameter of ditto, $1\frac{3}{4}$ in.; length of ditto, hæmal side, $\frac{3}{4}$ in.; ditto, neural side, $\frac{5}{8}$ in.; width of base of transverse process, *d*, 1 in.; length of upper part of ditto, $\frac{3}{4}$ in.; length of lower part of ditto, $\frac{3}{8}$ in.; *b* is the notochordal foramen; *e* is the probable base or floor of the neural canal; *f*, a restored transverse process. The only other illustrations of Coal-measure reptile vertebræ, of large size, with which I am acquainted, are a supposed vertebra of *Anthracosaurus*, figured by Professor Huxley in the *Quarterly Journal of the Geological Society*, vol. xix., p. 63; of *Eosaurus Acadianus*, in the *American Journal of Science*, March, 1862, N.S., vol. xxxiii., p. 278; and of *Pholiderpeton scutigerum*, a very imperfect vertebra, which is described by Professor Huxley, and figured in the *Quarterly Journal of the Geological Society*, vol. xxv., p. 310, plate 2.

The centrum, *a*, of the vertebra is strong and well ossified; it is bi-concave, and possesses a small notochordal foramen, *b*; the transverse process, *d*, has well-defined bifid characteristics, adapting it to the tuberculum and capitulum of the rib, with which it was articulated; the edge of the centrum is concave. Other large vertebræ, found in the same shale, have very strong, broad, well ossified neural processes which would afford attachments for dorsal muscles of great size, and consequent power.

Specimen, fig. 202, is represented of three-fourths the natural size, and has, I think, erroneously been ascribed to *Pteroplax cornuta*; *a* is the centrum; *b*, the notochordal foramen; *c*, the transverse process; *d*, the neural canal, and *e*, the neural spine.

Fig. 203 excellently illustrates a unique vertebra discovered by Mr. John Simm, of West Cramlington. The centrum or body of the vertebra, *a*, on the side exposed, which I think is the anterior aspect, is concave, and near the centre of it there is a small, but well defined, notochordal foramen, *b*. On the left side of the centrum, looking at it anteriorly, there is a well exposed transverse process, *c;* that on the other side appears to have been broken off; the neural spine, *e*, is beautifully displayed, and the neural canal, *d*, is large and very well marked.

Fig. 204.—Professor Owen, in the *Quarterly Journal of the Geological Society*, vol. xviii., pp. 238-244, describes and figures a number of Coal-measure fossils obtained from Nova Scotia; and among the fossils figured and described is a series of vertebræ named *Hylonomus* by the learned Professor. They very closely resemble the series No. 204 both in size and form, and it is not improbable, therefore, that the small vertebræ here illustrated are those of a species of *Hylonomus* similar to those discovered in the Coal Formation of Nova Scotia.

SUPPOSED SCAPULÆ.

Fig. 205.—I am indebted to Mr. Joseph Taylor, of West Cramlington, for the specimen of the supposed scapula, figured of natural size. The fossil is, so far as I am aware, unique, and, if not unique, is certainly rare, as, with the exception of a description in the *English Mechanic*, March 24, 1871, its discovery has not been recorded. From the form of the bone, from its minute structure as displayed in transverse section, and from the comparative roughness of the external surface, I infer that it is reptilian. The extremity marked *a* is concave, apparently for the reception of the upper extremity of the humerus, and the bone at the other end is thin and flat, for the attachment of the muscles of the shoulder girdle. A strong well-defined ridge

extends along its entire length, as is represented by the illustration.

Fig. 206, another supposed scapula, is more enigmatical than the former, and is equally rare. It is the only specimen of the kind I have seen, and I have not heard of another specimen having been discovered.

The only bone that it at all resembles is, so far as I have been able to discover, a scapula of *Megalosaurus*, a figure of which appears in the "Transactions" of the Palæontographical Society, vol. 1856, table V. The flat, spatular, pecten-like extremity, which is deeply grooved, bears a close resemblance to the grooved extremity of the scapula of *Megalosaurus;* but the opposite extremity differs materially from that of the huge old-world reptile.

HUMERI.

Figs. 207, 208, and 209 are illustrations of various forms of humeri or femora, probably of Reptiles, possibly of Cetaceans. It is not at all clear whether these stout, strong, short bones belonged to the shoulder or the pelvic girdles, but more probably the former. On the supposition that they are reptilian, they indicate that the limbs of Coal-measure reptiles were short and strong, and rather more adapted for progression in water than locomotion on land. So far as my investigations have gone, no remains of either anterior or posterior digital extremities have been found.

Fig. 210 represents a scapula, the articular extremity of which is deeply concave, and fits exactly the larger rounded extremity of the humerus No. 207; the flat extremity is ridgeless, like the scapulæ of Cetaceans, viz., whales, porpoises, dolphins, &c., and unlike the scapulæ of ordinary quadrupeds.

SCUTES.

Fig. 211 is representative of a scute of *Pholiderpeton scutigerum*, discovered in the roof of the Black Bed or Royd's

coal, at Loftshaw, near Bradford, and described by Professor Huxley in the *Quarterly Journal of the Geological Society*, vol. xxv., p. 310.

Fig. 212 is a fossil somewhat resembling the figured Bradford scute, found in our Coal-measures, belonging, I believe, to the head of a fish, and not to the dermal covering of a reptile. It is a remarkable fact that, while scutes in abundance have been found in other localities associated with large Labyrinthodont remains, no such scutes have, up to the present time, been found in this locality. The probability is, therefore, that the numerous huge Labyrinthodonts and Reptiles that inhabited the Northumbrian lagoons and shores of the Carboniferous era were not protected by scaly armour, as were those found in other localities, and as are crocodiles and other huge reptiles of the present day.

INSECTIVOROUS MAMMAL.

The left mandible, illustrated by fig. 213, has given rise to much animated, unnecessary, and heated controversy. Nearly four years ago, I expressed the opinion that the mandible figured was probably that of an insectivorous mammal, and some local palæontologists, without having seen the specimen, asserted that it was the mandible of a fish known as *Acanthodopsis*. Mandibles of *Acanthodopsis* are figured on plate iv., Nos. 106, 107, 108, and it will not be difficult for any one to recognise the great difference between the mandible of the supposed mammal and those of the *Acanthodean* fishes. The mandible now under consideration differs from those of all known Coal-measure fishes and reptiles, by having the posterior articular extremity turned up in a manner closely resembling the form of ordinary Mammalian lower jaws. It is stouter and stronger, in proportion to its bulk, than is the mandible of any known Coal-measure fish or reptile. It differs from both reptiles and fishes in the smallness of the number of the teeth, in their stoutness, and

in their blunt conical form. The recognised age of Mammalia has gradually been carried back from the Tertiary to the Oolite, and from the Oolite to the Trias, and, as Professor Huxley, on several occasions, has very philosophically remarked, there is no reason why Mammalia should not have existed in Palæozoic times, and why their remains should not be discovered in strata of Palæozoic age. During the Coal period, vegetation was both advanced and abundant, and, as their numerous remains prove, the lagoons, streams, and occasionally submerged land, teemed with fish, reptile, and insect life. Reasoning from analogy, it is more than merely probable that the dry land of the period was the habitat of numerous varieties of Mammalian life. The unfrequent, or, as some suppose, non-discovery of Mammalian remains in the coal shale may be accounted for by the fact that, with the exception of Cetaceans, Mammals for the most part occupy land, and are not accustomed to die and leave their remains in water. The improbability of discovering Mammalian remains in the black hardened mud which overlies the coal, and which has manifestly been deposited in more or less deep water, is not at all surprising, and the extreme rareness of Mammalian remains in a matrix formed under aqueous conditions is precisely what might have been expected.

The mandible has been seen by many skilled palæontologists, and, with one exception, they have acknowledged it not to be fish, and admitted that it is probably either a portion of an insectivorous reptile or an insectivorous mammal. One palæontologist who has had much experience in the anatomy of Australian marsupials was much struck by the resemblance which exists between their mandibles and that under consideration.

Chapter IX.

TRANSVERSE AND LONGITUDINAL SECTIONS OF RIBS, SCAPULA, TEETH, AND VERTEBRA OF COAL-MEASURE LABYRINTHODONTS AND REPTILES.

In the previous chapters and illustrations, I have endeavoured, as far as the means at my disposal enabled me, to give descriptions and illustrations of the fishes and reptiles that have been discovered in the Northumberland Low Main Coal Shale, and I now propose to describe and illustrate the beautiful minute structures of various portions of reptile remains, but more especially to exemplify the value of microscopic odontography as a means of discriminating between and identifying the numerous amphibians and reptiles that have been found, and to aid in the identification of the yet more numerous genera that will probably be found when our Coal Measures have been carefully and systematically explored. The probability of additional new genera of Coal-measure Labyrinthodonts and Reptiles being discovered in our yet imperfectly examined coal shales must be evident to all who have worked, or who are working, in this department of Carboniferous palæontology, and the necessity for a thorough revision of what is now supposed to be known is equally manifest, as I shall endeavour to show in the course of my remarks on the microscopical sections about to be described.

REPUTED RIB OF ANTHRACOSAURUS.

Figs. 214 and 215 illustrate transverse and longitudinal sections of a rib commonly ascribed to *Anthracosaurus*, each magnified four diameters. The transverse section shows that the rib is pierced longitudinally by numerous canals of various sizes, known as Haversian canals, the larger canals

being near the centre of the rib, and their dimensions gradually diminishing as they approach the periphery. The longitudinal section, No. 215, shows that the canals, the ends of which are visible in the transverse section, No. 214, traverse the rib longitudinally, in an irregular, partially vermiform, manner, and that they, in their course, frequently inosculate, presenting, in longitudinal section, the appearance of long irregular cavities, and in transverse section cavities of various sizes. Scattered at various intervals between the canals, are dark irregular spaces recognised as lacunæ, and from those lacunæ small canaliculi proceed forming minute channels for bone nourishment. In the centre portion of the longitudinal section, the canals are very distinct, but on the external part of the rib, when seen in longitudinal section, the canals are very short and irregular, and the structure has the appearance of bone in a minute state of comminution. This fragmentary condition has probably been caused by injury received. Both the external and internal cavities of the rib are filled with white semi-opaque matter, composed probably of some form of lime, and resembling exactly the solid mass of lime-like substance which fills the large central or other cavities in the spines of *Orthocanthus*, *Pleuracanthus*, *Gyracanthus*, *Ctenacanthus*, and other Coal-measure Selachians. The matter which generally fills the cavities of those Coal-measure spines and ribs differs entirely, both in composition and colour, from the black, oleaginous matrix in which the fossils lie embedded.

RIB OF MACROSAURUS POLYSPONDYLUS. *(Barkas.)*

Figs. 216 and 217 are representations of transverse and longitudinal sections of an undoubted rib of *Macrosaurus*, magnified four diameters. The most casual examination of the sections of this and the previously described rib will enable any palæontologist to recognise that the structures are widely different. The Haversian canals in the ribs of *Macro-*

saurus are less numerous, the walls which surround the canals are at least double the thickness of those of the so-called *Anthracosaurus*, the bony structure itself is more dense, and the osseous matter is of a deeper brown colour than is that of *Anthracosaurus*. The longitudinal canals visible in longitudinal and transverse sections are not only larger than those of *Anthracosaurus*, but they are completely filled with the semi-transparent calcareous matter which gives the sections a solid appearance, being equally composed of dark brown bone and white intermixed matter. The difference in the minute structure is easily recognised in the illustrations, and yet more easily in the natural sections, and the lacunæ and canaliculi are distinctly visible. The ribs not only differ in structure, but they differ greatly in form; the supposititious ribs of *Anthracosaurus* being broad, flattened, and concave on the broad surface, whilst those of *Macrosaurus* are oval, approaching circular, the longer axis of the section being little greater than the shorter. Other ribs not belonging to either of the genera have been found, but, with the exception of one associated with a cranium and several vertebræ of *Pteroplax*, all have been discovered in a state of isolation, and therefore it is impossible to say to which of the many Reptiles and Labyrinthodonts of the Coal period they belong. As no sections, either longitudinal or transverse, of ribs of Coal-measure Reptiles or Labyrinthodonts have, prior to those associated with this chapter, been published, I am unable to compare them with any that have been found in this or other localities.

A REPTILE SCAPULA.

Fig. 218 is a transverse section of a reptile scapula (or it may be clavicle), magnified four diameters, the entire form of which is represented of natural size by fig. 205, in a previous sheet of illustrations. The section is taken from near the centre of the shaft, and the structure in section much

resembles that of the rib of *Macrosaurus*, the chief difference being that the Haversian canals are smaller, more numerous, and extend in greater numbers to near the surface of the bone. The osseous matter is greater in the scapula than in the rib; the scapula, therefore, in proportion to its size, is stronger and more compact than is the rib.

REPUTED TEETH OF PTEROPLAX CORNUTA.
(*Hancock and Atthey.*)

Figs. 219 and 219[a] represent sections of the reputed teeth of *Pteroplax cornuta*, natural size, and magnified four diameters. The genus *Pteroplax* was founded upon a cranial shield, or rather portions of cranial shields, found in the shale of the Northumberland Low Main Coal seam. In the same shale, but at different times, portions of jaws and vertebræ have been discovered, which were supposed to belong to *Pteroplax*, but the evidence of their being jaws, teeth, and vertebræ of *Pteroplax* is, with the frequent discovery of specimens of other large genera in the same shale, gradually becoming weaker, until the probabilities now clearly lie on the side of the teeth, jaws, and vertebræ not belonging to the genus which was founded on the peculiar cranial shields which have been designated *Pteroplax*.

The teeth now known as those of *Pteroplax* were originally described by Messrs. Kirkby and Atthey, in the "Transactions" of the Tyneside Naturalists' Field Club, vol. vi., p. 234, as *Rhizodus lanceiformis*, which they certainly very slightly resemble; the same teeth were next named by Professor Owen, in his "Dental Characters of Genera and Species of Fishes from the Low Main Seam and Shales of Coal, Northumberland," p. 37, plate viii., as *Mioganodus laniarius*; and they have subsequently been named by Messrs. Hancock and Atthey, in the "Transactions" of the Tyneside Naturalists' Field Club, New Series, vol. iii., p. 70, as *Pteroplax cornuta*. Notwithstanding the name ordeal through which

these lanceolate teeth have passed, there is very great probability that the roll of changes has not yet terminated.

So far as the published information respecting the teeth is concerned, there is no satisfactory proof that they belong to *Pteroplax* at all. Certain premaxillary bones with rather flattened teeth, certain fragments of mandibles with more flattened teeth (fig. 195), and certain strong vertebræ with transverse and neural processes (fig. 202), have been discovered in the same shale, and have been attributed to *Pteroplax*, but now that many different Labyrinthodonts have undoubtedly been found, there is little reason for ascribing the teeth and vertebræ to *Pteroplax*, and much reason for believing that neither teeth nor vertebræ belong to that Labyrinthodont. The chief reasons for doubting the Pteroplaxian ownership of the teeth being, that the jaws and cranial shields have not been found together, that the jaws which have been found are too large for the crania, that there are several other Labyrinthodonts and Reptiles, to some of which the teeth may with equal, perhaps more propriety, be said to belong, and especially to *Macrosaurus polyspondylus*, with the remains of which I found a so-called *Pteroplax* tooth.

With respect to the vertebræ, there is great reason for believing that the vertebra which was supposed to belong to *Pteroplax*, which is illustrated by fig. 202, is not a *Pteroplax* vertebra, a cranial shield of *Pteroplax* having been discovered associated with several vertebræ of large size, none of which have either neural or transverse processes, all of which have notochordal foramina, larger than is that of the centrum attributed to *Pteroplax*, and some of them nearly as large as the centrum illustrated by fig. 199. With these facts before us, we may fairly infer that *Pteroplax* has centra with large notochordal foramina, and that the flattened teeth cannot legitimately be allotted to that genus, as they may, with equal or greater propriety, be recognised as teeth of some of the many Reptiles or Labyrinthodonts of

the Carboniferous strata. Another reason for believing that the reputed teeth of *Pteroplax* do not belong to the Labyrinthodont having the peculiarly horned cranial shield illustrated by fig. 191 is that the teeth, both singly and in jaws, are far from unfrequently found in the Northumberland shale, while the crania are exceedingly rare, and so far as I am aware, the crania that have been found have never been obtained with the peculiar flattened teeth associated with or attached to them.

After this digression, I have to direct the attention of my readers to figs. 219 and 219[a]. Fig. 219 is a longitudinal section of a tooth of the reputed *Pteroplax*, of natural size; and 219[a], the same tooth magnified four diameters. The section is not precisely through the centre, and the tooth is therefore altered in outline to a slight extent. The teeth are considerably carinated, and the typical form is better recognised by reference to fig. 195, the teeth in which, although a little obtuse at the apices, more closely approach the natural form. The portion of the tooth, marked *a*, is the pulp cavity, which is filled with a dark matrix and bony fragments. The substance of the tooth or dentine, *d*, is very dense, and is permeated by small dentinal tubuli which radiate in curved lines from the pulp cavity to the lateral and apical parts of the tooth. Well-preserved teeth are more or less covered by a thin coating of enamel, but the tooth which furnished the illustration has had its enamel eroded or rubbed off.

Fig. 219 represents a tooth of average natural size, but many specimens have been found much larger and others much smaller than that figured.

The teeth, because of the denseness of the dentine, are peculiarly brittle, and it is with great difficulty that a good section can be made for microscopical examination, as the lanceolate flatness of the teeth and the brittleness of the dentine combine to render them very friable and difficult of manipulation. Fig. 220 is a transverse section of a reputed *Pteroplax* tooth, taken near the summit of the pulp cavity

at about one-half the distance between the base and the apex. When examined by a low power, the section has a compact, homogeneous appearance, but when examined by higher optical power, sections of the canaliculi or dentinal tubuli present themselves as represented in the transverse section. There is not the slightest indication of that radiate structure which is so characteristic of some of the accompanying dentinal illustrations. In another transverse section taken nearer the base, there is the same absence of radiate structure, but it is not improbable that within the jaw the teeth may, like those of *Megalichthys*, have a distinctly convoluted or radiate form. The structure of the teeth of *Megalichthys*, out of the jaw, is perfectly simple and layer-like, but within the alveolar border they are characterised by extensive convolutions.

AMPHISAURUS AMBLYODUS. (*Barkas.*)

The transverse section of a tooth which is indicated by fig. 221 is the first of a remarkable series of sections of Reptile and Labyrinthodont teeth which have been rubbed down and mounted for microscopic examination by Messrs. Simm and Taylor, of West Cramlington, from specimens in their cabinets and in my own. The section from which the figure is taken is from a tooth from a portion of a jaw in the possession of Mr. John Simm, and corresponds with a larger fragment of a mandible in my possession. The teeth of *Amphisaurus amblyodus* are of nearly uniform size, and the mandible in my possession is represented by fig. 192. The section is taken from a part of the tooth about $\frac{3}{8}$ in. from the base, and the sketch, No. 221ª, represents the natural size of the tooth. The teeth, which this is said to resemble, are those of *Anthracosaurus*, which Professor Huxley, in the *Quarterly Journal of the Geological Society*, vol. xix. p. 61, describes as follows:—"Transparent transverse sections of the teeth exhibit a singularly beautiful and complex struc-

ture. The relatively small pulp cavities send off primary radiating prolongations, which pass straight to the circumference of the tooth, and, at a small distance from it, terminate by dividing, usually, into two short branches, each of which gives off from its extremity a wedge-shaped pencil of coarse dentinal tubuli. These spread out from one another and terminate in a structureless or granular layer, which forms the peripheral portion of the dentine, and, from the small irregular cavities scattered here and there through its substance, reminds one of the globular dentine of the human tooth. An extension of this peripheral layer is continued towards the centre of the tooth, between every layer of primary prolongations of the pulp cavity. The short secondary processes which are sent out from opposite sides of the primary prolongations of the pulp cavity give off in the same way, from their ends, pencils of conspicuous dentinal tubuli, the ends of which terminate in the inward extensions of the peripheral layer. The secondary processes of adjacent primary prolongations alternate, and, as it were, interlock with one another, so that the inward extension of the peripheral layer takes a sinuous course between them. A thin layer of dense and glassy enamel invests the tooth continuously, but sends no processes into its interior, and, of course, under the circumstances, there can be no cement in the interior of the tooth, nor can its surface be said to be plaited or folded. It will be understood that this description gives merely the principle of arrangement of the parts of the tooth; its details could only be made intelligible by elaborate figures."

Illustration 221 presents the appearance of a section of a tooth of *Amphisaurus* magnified ten diameters. The leaf-like double, triple, and quadruple radii are well exposed. From the whole of the apices of the leaf-like radii, there run vermiform semi-translucent lines, probably of cement, which follow their undulating course through the dentine of the tooth, *d*, and unite or coalesce in the bases of the compound radii just before the radii terminate in the central pulp

cavity, *a*. The interspaces between the points of the radii which touch the circumference of the tooth are crowded with strong dentinal tubuli that also terminate at the periphery, and between these portions of the dentine, filled with large tubuli, and the parts in which the radii at their bases come into contact, there are large spaces, like secondary lateral pulp cavities, that form large irregular longitudinal canals in the substance of the tooth. In the diverging leaf-like radii, when examined by high powers, there are many pencils of tubuli seen to penetrate the concavities of the vermiform radial undulations, the bases or roots of those secondary groups of dentinal tubules being in the margins of the interspaces between the primary radii. These fan-like tubuli are faintly indicated in the sketch. When a yet higher magnifying power is applied, final dentinal canaliculi are seen to pervade the entire mass of dentine which forms the body of the tooth, and by means of a power of 200 diameters these fine tubules are seen to terminate along the borders and not to enter the vermiform lines of cement that run in their undulating course down each of the primary radiations and unite with the clear coating of cement which invests the exterior of the tooth; the external cement is also not penetrated by the dentinal canals. Although the specimen is very complete and the external margin of the tooth is well preserved, there is not any indication of a covering of enamel, which, according to Professor Huxley, is present on the teeth of *Anthracosaurus*, which is beautifully displayed and uniquely applied to the surface of the teeth of the next reptile to be described.

Fig. 221[a] illustrates the form of the tooth, average natural size, the surface being striated at rather broad intervals; the apex is blunt, and the shaft near the apical extremity suddenly turns at an obtuse angle.

Fig. 222 presents a section of a tooth of *Amphisaurus*, taken within half an inch of the apex, and in it there are no indications of that radial structure which is so beautifully

characteristic of the teeth nearer the base. The central or yellow portion of the tooth immediately surrounding the pulp cavities is formed of a series of dentinal layers closely resembling the annual rings observed in sections of trees. The dark, or outer portion of the tooth, *d*, is characterised by radiating dentinal tubules which, at intervals, are aggregated into dense clusters, and there are very faint indications of gradual depositions of dentine.

LABYRINTHODONTOSAURUS SIMMII. (*Barkas.*)

The tooth illustrated by figs. 223, 223[a], and 224 belongs to the jaw represented by fig. 194, and, like several specimens described in these pages, is new to science. In many respects, the configuration of this remarkably beautiful tooth is unique, especially in the peculiar arrangement of the enamel. The tooth at the base is characterised by deep sulci; the shaft is partially covered by nearly parallel and well-defined ridges which resemble those on the well-known teeth of *Strepsodus*. The section of the tooth from which the illustration No. 223 was taken is from a little below its place of insertion in the jaw, and surrounding the section there is a portion of the alveolar border of the jaw. The entire character and configuration of the tooth bear a remarkable resemblance to the tooth of *Ichthyosaurus*, illustrated in pl. 64 *B*, fig. 3, of Owen's "Odontography," and described by the learned Professor in his description of the teeth of the Enaliosaurs on page 279 of the same work.

The structure of the tooth, as may be seen at a glance, if it be compared with those that accompany it on the sheet of illustrations, differs entirely from those of the known local Labyrinthodonts and Reptiles of the Carboniferous period, the whole of which, with the single exception of *Labyrinthodontosaurus*, have leaf-like radii, proceeding from comparatively small pulp cavities, through which radii vermiform

lines of cement pass and unite with the cement that covers the teeth.

In the teeth of *Labyrinthodontosaurus*, however, no such arrangement exists; there is an entire absence of vermiform cement lines, and the tooth does not consist of perpendicular, compound, leaf-like shafts of light coloured dentine, with large external interspaces filled with dark coloured dentine, crowded with large calcigerous tubes, as *d*, fig. 221, and numerous minor pulp cavities at the apices of the dark pyramids of dentine *d*, which are wedged between the radii and form the greater part of the external surface of the tooth, fig. 221. On the contrary, the teeth of *Labyrinthodontosaurus* at their bases may be said to consist of hollow convoluted cones of dentine, with deep sulci or depressions both external, *d*, and internal, as though they consisted of thick masses of substance folded and bent into hollow conical forms.

The convoluted nature of the dentine or mass of the tooth will be best understood by reference to the illustration, fig. 223.

The sulci on the external surface of the tooth are dipped into, and filled, by the bone of the alveolar edge of the jaw, and the internal sulci are filled by the contents of the pulp cavity. The convolutions of which the dentine is composed are marked with alternate dark and light bands, that follow the sinuosities of the convolutions. Over both the dark and light bands the dentinal tubuli proceed, and the bands of comparative lightness appear to be produced by the fineness of the tubules in those localities. The circumference of the tooth is covered with a thick coat of cement, which follows the convolutions of the sulci, but into the cement on the crests of the undulations, and in the sulci or deep depressions, the calcigerous tubes do not enter. The cement, when examined by a power of 200 diameters, appears to be structureless, and as I have already stated, it invests the entire tooth. On the crest of each external convolution, there is a thick coat of glassy enamel, which is thickest on the sum-

mits of the convolutions and gradually diminishes in thickness until it terminates with a wedge-like edge at the entrances of the sulci. The enamel does not, in any case, dip with the cement into the external depressions, but merely protects the external and exposed aspects of the elevations. In this respect, I believe the placing of the enamel is unique, and, so far as my investigations and reading have gone, no such arrangement of enamel is known to exist, except on the teeth of *Labyrinthodontosaurus*.

Fig. 233[a] is a typical form of one of the larger teeth of *Labyrinthodontosaurus*. It is nearly circular in outline, and although it somewhat resembles in external appearance the teeth of *Strepsodus*, it has not the peculiarly recurved apex that is specially characteristic of the tooth upon which the genus *Strepsodus* was founded.

Fig. 224 represents a section of a tooth of *Labyrinthodontosaurus*, taken from near the apex, which, when examined by a low magnifying power, presents the appearance represented by the sketch, and it, in some respect, conforms to the radial structure of some of the teeth, figures and descriptions of which will subsequently be given. From the pulp cavity *a*, to the periphery of the tooth, diverging lines of large calcigerous tubuli proceed, and those dentinal tubes, which are very numerous and closely arranged, terminate at the inner edge of, without penetrating the cement which invests the tooth.

When a higher microscopic power is applied to the section, it is seen that the radii, which in the figure contain small elongated ovals, are penetrated with what I may, for want of a better term, designate solid sulci, corresponding with the external sulci of fig. 223, except that there are no spaces for the introduction of osseous or other matter, which in fig. 223 are marked *d;* and into those solid sulci the cement enters, but into the cement the calcigerous tubes of the dentine do not penetrate. The tooth, near its apex, is entirely covered by a coating of dense glassy enamel.

LOXOMMA ALLMANNI. (*Huxley.*)

Fig. 225 is a basal section of a tooth commonly attributed to *Loxomma*. The teeth found in our Coal Shale, that are supposed to belong to *Loxomma*, are large, stout, and strong; the base of each tooth is nearly circular, but the form rapidly changes as it approaches the apex, and near the apex it is much compressed, and very lanceolate. These teeth, at their bases, are more deeply grooved longitudinally than are any other Coal-measure Reptile or Labyrinthodont teeth with which I am acquainted.

Professor Huxley, in his original description of *Loxomma* in the "Proceedings" of the Geological Society, vol. xviii., 1862, pp. 292-294, does not refer to the teeth, because all that was then positively known of the Labyrinthodont was the small fragment of its cranium, fig. 190. In addition to the fragment of a cranium, Professor Huxley examined from the same locality some Labyrinthodont sternal plates, which, because of their having been found in the same stratum, he attributed to *Loxomma*. As many Labyrinthodont remains have now been found in Scottish and English Carboniferous Strata, it is not at all improbable that those median and lateral-sternal plates belong, not to *Loxomma*, but to some other of the many Labyrinthodonts that are now known to have existed during the Carboniferous epoch. The next record of the probable occurrence of *Loxomma* appeared in *Scientific Opinion*, vol. ii., August 18th, 1869, p. 235. That was followed by a paper by Messrs. Hancock and Atthey, in the *Annals and Magazine of Natural History*, May, 1870, and in the "Transactions" of the Tyneside Naturalists' Field Club, New Series, 1871, vol. iv., pl. 1, pp. 201-208; and subsequently another paper appeared in the *Annals and Magazine of Natural History*, 1871, vol. vii., p. 77. At the meeting of the British Association, held in Exeter in 1869, Mr. James Thompson, of Glasgow, read a

paper on specimens which he attributed to *Pteroplax*, but which Messrs. Hancock and Atthey ascribed to *Loxomma*.

The section, fig. 225, as may be seen at a glance, differs greatly from all other sections yet described. The pulp cavity, *a*, is large, and nearly circular, and the radiations from the central pulp cavity which divide the dentinal radii are very large, and extend nearly to the periphery of the tooth. Some of these radial pulp spaces are nearly continuous from the centre to the circumference of the tooth, and others are interrupted. Both the central and radial pulp cavities are filled with a dense mass of lime-like substance, which glistens when examined by transmitted artificial light. The dentinal radii are extremely unlike the radii of *Amphisaurus*, fig. 221, inasmuch as they are as vermiform as are the dark broad central lines which pass through them, the undulations of the central dark lines being followed by the undulations of the dentinal radiations. The external inflexions of the tooth, instead of being broad and few, as in *Labyrinthodontosaurus*, fig. 223, are small and numerous, and instead of the transparent coating of cement which covers and penetrates, with vermiform lines, the tooth of *Labyrinthodontosaurus*, there is continued round the tooth of *Loxomma* a dense broad dark coating, analogous to, and continuous with the broad dark vermiform lines which pass through the centres of the vermiform dentinal radii. There is not, in the section of the tooth, the least indication of cement surrounding the tooth, nor is there the slightest trace of enamel. The osseous matter in which the tooth was originally inserted, and which now surrounds it, is full of large Haversian canals, and crowded with large lacunæ.

DOUBTFUL REPTILE TEETH.

Figs. 226 and 227 represent sections of teeth that have been crushed in the matrix, and the pulp cavities of which, as a result of the crushing, present a flattened appearance.

Although the teeth were taken from different jaws, yet in minute structure the two sections closely resemble each other, and appear to be portions of the teeth of the same genus. The spaces marked *d* are filled with coarse dentinal tubules, which resemble those in similar parts of *Amphisaurus* (fig. 221, also marked *d*), and the single leaf-like radii, besides having passing through their centres very faint vermiform cement lines, are filled with slightly flexed calcigerous tubes, which form longitudinal light and dark growth lines, resembling similar lines in trees when examined in longitudinal section. On both teeth there is a slight appearance of an external covering of cement, and on section fig. 226, there remains a small fragment of dense enamel.

ANTHRACOSAURUS RUSSELLI. (*Huxley.*)

This tooth, three transverse sections of which are represented by figs. 228, 229, 230, and the root of which, inserted in a portion of the jaw, is illustrated by fig. 231, is taken from a reputed left mandible of *Anthracosaurus*, the form and size of the articular extremity of which are represented by fig. 193; a description of the enormous jaw accompanied the figure in a previous chapter. I have, since that description was written, obtained a larger portion of a reputed right mandible of *Anthracosaurus*, which is quite as long as that previously described, viz., 20 in., and may be its fellow. Associated with the right mandible, and lying in close proximity to it, is a very fine reptile centrum, which, in all probability, belongs to *Anthracosaurus;* it is $1\frac{7}{8}$ in. in its longer, and $1\frac{3}{4}$ in. in its shorter diameter. The notochord, though visible, is extremely small; the centrum is deeply bi-concave, and remarkably well ossified. The length of the vertebra in the antero-posterior direction is, on what appears to be the upper aspect, $\frac{7}{8}$ in., and on the hæmal side, $\frac{3}{4}$ in. The sides of the vertebra are deeply but not uniformly concave, there being well marked elevations and depressions on

the concave edge, which has a distinct and fresh-looking semi-gloss. There are not the slightest indications of either neural, hæmal, or transverse processes. An entire tooth of *Anthracosaurus* is represented by fig 228ª. The portion of the left mandible from which the tooth which supplies sections 228 to 231 was taken is 4 in. from the symphysial or anterior extremity, and the tooth and fragment of jaw were cut from the solid mandible.

The external alveolar border of the jaw rises about ¼ in. above the interior alveolar border; and section No. 228, was taken on a level with the higher border of the jaw, and about one-fourth of an inch from the true insertion of the tooth. Section No. 229, was taken from the level of the lower alveolar border; section 230 from a portion of the tooth inserted in the substance of the jaw; and fig. 231 is a perpendicular section of the root of the tooth and the substance of the jaw beneath the level of the transverse section No. 230.

The radii in section No. 228 are, for the most part, single; three of them are double, and one is triple. The radii extend from the pulp cavity *a* to the periphery of the tooth, and are in form much more irregular and broad at the bases than are those in *Amphisaurus*. The undulating lines of cement which pass through the radii are stronger and broader than in *Amphisaurus*, and the undulations are bolder and less numerous.

The interspaces between the summits of the radii are filled with dentinal tubules, and are beautifully marked by alternate light and dark transverse shadings, which present the appearance of the fronds of the Alga *Padina pavonia*. The tooth is covered by a thin coating apparently of cement, and outside the cement is a dark band, which either represents the terminations of the calcigerous tubes or an inner appendage to the osseous structure of the jaw.

Fig. 229 is a section of the same tooth more or less surrounded by the dentary bone in which it was inserted. The

external surface of the tooth, according to fig. 228, may be described as undulating, there being a wavy surface, but no absolute sulci; the section No. 229 represents distinct but not deep sulci, or longitudinal furrows, into which the jaw penetrates in a manner similar to, but not so deeply, as in the tooth of *Labyrinthodontosaurus* (fig. 223).

The general character of the tooth at section 229 resembles that of section 228, except that the undulating waves in the radii are much deeper and more involved than are those in the previous section, and the undulating cement lines are curiously marked at frequent intervals by transverse dark lines. The external surface of the tooth is covered by a very dark coat, which dips into the sulci, but does not penetrate the substance of the tooth. Fig. 230 represents a section of the tooth taken from quite within the substance of the ramus. It, in its general aspect, closely resembles section 229, the chief difference being that while, in the former, the tooth is surrounded by a dark, coarse coating, in the latter the dark coat is present, but is coated externally by a distinct covering of, apparently, structureless cement, which cement is continuous with the vermiform lines which penetrate the radii.

Fig. 231 is a beautiful longitudinal perpendicular section of a portion of the mandible, in which is inserted the compound basal extremity of the tooth as indicated by *a*. The compound root or roots of the tooth are inextricably involved in the osseous matrix, which adheres to the sides of the tooth, and enters between its irregular basal roots. The dentinal tubules are manifest in the base of the tooth, and the mass of jaw in which the tooth is fixed is, like all reptile bones, filled with huge Haversian canals and interspaces, which are crowded with dark pigment-like lacunæ.

ORTHOSAURUS PACHYCEPHALUS. (*Barkas.*)

Except the cranium, which is represented by figs. 183, 184, and 185, nothing whatever is known of this large reptile; and the tooth, a section of which is represented by fig. 232, is taken from the right side of the premaxilla, represented by fig. 183. By the absence of both vomerine and palatal teeth, the cranium differs from those of all known Coal-measure Labyrinthodonts, and although the tooth, in a general way, may be said to resemble those of other Coal-measure Reptiles, there are marked and peculiar minute differences which readily separate it from the teeth of all other reptiles.

The teeth are very nearly circular in form, and are grooved by a series of rather deep furrows, between which are well-defined narrow ridges. The pulp cavity is large, and the radii from the pulp cavities do not enter between the dentinal radii so frequently and distinctly as in the other teeth figured. Between the dentinal radii there are very large secondary pulp cavities, which do not visibly unite with the centre or primary cavity.

From the secondary pulp cavities, very dark and large dentinal tubules spring, and proceed to the periphery of the tooth. The dentinal radii, unlike those in the other teeth figured, are nearly parallel from base to apex, and rapidly converge to a very blunt extremity near the external surface of the tooth.

The tooth is encased in a well-defined cover of cement, beneath which lies a very dark, rough layer, apparently consisting of terminations of dentinal tubes. The cement penetrates each of the dentinal radii, and runs down them in an extremely vermiform manner, the windings of the convolutions being deeper and more acute than in any of the other teeth described. The rough, dark line beneath the external cement accompanies the enamel into the substance of the

tooth, and covers each side of the penetrating cement a considerable distance within the tooth. The crest of each convolution of cement gives off a process or spur of cement, which nearly reaches the edges of the radii, and the internal structure of the tooth is more involved than is that of any of the teeth previously described. There is not the slightest indication of enamel on the surface of the tooth.

REPTILE VERTEBRA.

Fig. 233 is an excellent illustration of a microscopic section of a reptile vertebra, magnified two diameters. The chief feature in the vertebra is its possession of a large notochordal foramen, which is indicated by the dark space in the centre of the illustration.

The Coal-measure reptile vertebræ differ much in size, in form, in the presence or absence of notochordal foramina, and in the possession or non-possession of transverse, neural, and other processes.

The vertebra figured is commonly referred to *Loxomma*, but there is now more reason for believing that vertebræ with notochordal foramina of the size indicated belong not to *Loxomma*, but to *Pteroplax*, as splendid remains of *Pteroplax*, associated with vertebræ having moderately large notochordal foramina, have now been discovered. This vertebra has a true bony structure, being crowded with numerous and large Haversian canals, and being sparsely supplied with lacunæ.

Chapter X.

JAWS OF NEW GENERA OF LABYRINTHODONTS OR REPTILES; VERTEBRÆ AND COPROLITE OF REPTILIA OR AMPHIBIA IN A NEW HORIZON; TEETH OF NEWLY DISCOVERED REPTILES; CRANIAL PLATES, TEETH, AND HEAD BONES OF CTENODUS; AND A SUMMARY OF THE VERTEBRATA OF THE NORTHUMBERLAND CARBONIFEROUS STRATA.

Recent discoveries of remains of Coal-measure Vertebrata are strongly confirmatory of the often expressed opinion that little has yet been done towards exhausting the remains of the Fishes, Labyrinthodonts, and Reptiles that lie buried in our comparatively little explored Northumberland Coal Strata.

During the comparatively short interval which has elapsed since these chapters were commenced, there have come into my possession many fossil remains from various Northumberland localities, some of which I now propose to describe and enter as novelties in the long and ever-increasing register of Palæozoic Faunæ.

AMPHICŒLOSAURUS TAYLORI. (*Nov. Gen.*)

I have first to direct the attention of my readers to the discovery of reptilian vertebræ and a large coprolitic mass in the post or fine-grained micaceous sandstone which overlies the Northumberland High Main Coal seam. The discovery of vertebræ in the strata associated with the High Main Coal is, so far as I have been able to ascertain, an absolutely new discovery, and the credit of it belongs to Mr. Joseph Taylor, of West Cramlington, who found the three vertebræ I am about to describe, and to whom also belongs the credit of discovering, on a subsequent occasion, and in my presence, a mass of coprolitic matter, in the post of the High Main Coal Seam. The average distance between the Low Main and the High Main Seams is about 360 ft.

In the shales and posts associated with the High Main Coal, immense masses of ordinary Carboniferous fossil ferns and other flora are commonly found, and the previous non-discovery of animal remains led investigators to infer that they were absent. Mr. Taylor's discovery, therefore, opens an entirely new field for research, and the research is the more attractive, because not only have bony remains of Labyrinthodont or of Reptilian vertebrata been found, but, associated with them, and nearly at the same time, the exuvia of a large animal, probably a reptile, has also been discovered. The vertebræ are three in number, they are in consecutive order, and gradually diminish in size. The diameter of the largest vertebra is 1 in., that of the smallest is $\frac{7}{8}$ in. The centra are Amphicœlian, or slightly bi-concave, and the sides of the centra in their antero-posterior direction are also concave.

There appears to be in each centrum a notochordal foramen, but it is so small and indistinct as to be doubtful. The centra have been crushed obliquely, and are a little altered in form, but that they are vertebræ cannot for a moment be doubted by any one acquainted with fossil reptilian remains. The three vertebræ together and separately are represented by figures 234[a], 234[b], and 234[c]. The dark spots in the centres of the vertebræ represent the small notochordal foramina. I propose provisionally to name the animal to which these vertebræ belonged *Amphicœlosaurus Taylori*. The coprolite discovered in the same stratum as the vertebræ is full of interest, as a microscopical examination of the contents of the exuvia shows that it is the product of a vegetable feeder. All the coprolitic remains from the Low Main that I have had an opportunity of examining demonstrate the carnivorous nature of their producers, as in all of them there are remains of comminuted bones, teeth, and other animal matter; while, in the coprolite from the High Main, there are not any indications of animal remains, and there is the manifest presence of the fibrous remains of plants. Fig. 235

represents a small portion of the fibrous contents of the coprolite, under a magnifying power of 150 diameters; the external parts of the fibrous matter are a dark brown, and the interiors are striated, as per figure. I deem it desirable to state that this section has been seen by one of the chief Coal Measure palæontologists in London, and he does not accept my interpretation of the vegetable nature of the contents of the coprolite.

These discoveries greatly increase the interest felt in the investigation of the High Main, and will, doubtless, be the means of stimulating to further investigations in that little explored stratum.

LEPTOGNATHOSAURUS ELONGATUS. (*Nov. Gen.*)

The mandible on which I propose to establish this new genus is in a very perfect condition, and is well exposed in the matrix of black shale in which it was discovered. The fossil is a left mandible, and its length is $6\frac{1}{4}$ in.; its depth at the centre of the articular extremity is 1 in., and it gradually diminishes in depth posteriorly and anteriorly. At a distance of $1\frac{1}{2}$ in. from the posterior extremity, the mandible is $\frac{5}{8}$ in. deep, and gradually diminishes in depth to the distal end, which is $\frac{3}{8}$ in. deep.

The internal and external surfaces of the mandible are well exposed; the outer surface is covered with the deep furrowed pittings which are characteristic of the surfaces of reptile bones, and the inner surface, instead of being comparatively smooth, is covered with numerous deep pittings, that, unlike the external depressions, are not confluent, and do not form more or less elongated grooves. The teeth, which are of nearly uniform size, are $\frac{1}{2}$ in. in length, and they are placed at an average distance from each other, measuring from centre to centre, of $\frac{3}{8}$ in. In one or two instances they approach more closely, and in others they stand more widely apart, but, taken as a whole, the intervals between the teeth

are singularly regular. There are sixteen teeth in the jaw; the first is close to the symphysial extremity, and the last is $1\frac{1}{2}$ in. from the proximal end. The teeth are cylindrical, slightly curved at the apices, and smooth on the surfaces, with the exception of very delicate grooves near the bases, which extend about one-third along the shafts of the teeth. I propose, in accordance with the form and leading characteristics of this mandible, to name it *Leptognathosaurus elongatus*. The mandible is represented by fig. 236.

The Carboniferous Amphibian that most closely approaches *Leptognathosaurus* in size of jaw, form of teeth, and general dentition is *Pholiderpeton scutigerum* of Professor Huxley, described in the "Proceedings" of the Geological Society, vol. xxv., p. 310.

STREPTODONTOSAURUS CARINATUS. (*Nov. Gen.*)

In size, form, and arrangement of the teeth, the mandible about to be described, and which is represented by fig. 237, more closely resembles that just described than does the mandible of any other known Labyrinthodont or Reptile of the Coal period, but the differences between them are so great that the most casual observer could not fail at once to recognise them. With the exception of the articular extremity, the mandible is perfect, but, unlike that just described, it is a right mandible, and the inner surface alone is fully exposed, the outer, or rather the under surface being a little exposed near the posterior extremity. The length of the portion of the mandible in my possession is $7\frac{1}{4}$ in.; its greatest depth, which is near the centre, is $\frac{11}{16}$ in.; its depth at the symphysial extremity, *a*, is $\frac{8}{8}$ in.; and, at the posterior extremity, *b*, the angular or articular bone being absent, the depth is $\frac{1}{4}$ in.

The teeth, which are twenty-two in number, are arranged at nearly uniform distances from each other, the first being

close to the distal extremity and the last within $\frac{3}{4}$ in. of the posterior end of the jaw.

The alveolar border of the jaw is strong, thick, and protruding, and the jaw on its inner aspect is highly polished. The teeth are set in a uniform row, just within the border of the alveolar ridge, and are beautifully exposed from bases to apices. The teeth are of nearly equal length, viz., $\frac{1}{2}$ in. Their bases are nearly circular; they curve gently and gracefully towards their apices, which are doubly lanceolate or carinated, with a sharp keel-like ridge on each edge, and in the antero-posterior direction of the jaw. At the bases, and two-thirds along each tooth, there are deep grooves, and between the grooves, as is the case in *Orthosaurus*, there are distinct semi-circular elevations.

Each tooth at its immediate base is covered with fine pitted fret work, as though a portion of the osseous border of the jaw extended up the teeth. I propose to name the reptile having jaws with the peculiarities just enumerated *Streptodontosaurus carinatus*, the name being founded upon the peculiar lateral bend of the teeth and the carinated or keel-like edges which they possess.

These two mandibles are undoubtedly unique. They do not correspond with any jaws that have previously been described, and the only doubt on my mind relating to them is, whether one of them does not legitimately belong to *Pteroplax cornuta*, as they more nearly correspond with the sizes of the cranial shields of that Amphibian than do any that have been discovered, and are certainly more likely to belong to it than are the large mandibles that have hitherto been attributed to it. Unlike the supposed *Pteroplax* jaws which have been found in considerable numbers, they quite equal in rarity the cranial shields of that Labyrinthodont, and, taking into account the size, rarity, and surface markings, one of them may ultimately be ascertained to belong to that little-understood air-breather.

A NEW BATRACHIAN.

Figure 238 is a sketch of an inner or lower aspect of a cranium of what appears to be a new Batrachoid form of Coal Measure vertebrate. The Coal Measure Batrachian it most nearly resembles is that known as *Batrachiderpeton lineatum*, but it differs from that Batrachian in so many particulars that it cannot for an instant be referred to it.

According to the illustration of the inner aspect of the cranium of *Batrachiderpeton*, given in the "Transactions of the Tyneside Naturalists' Field Club," vol. iv., part 1, plate 4, fig. 1, the head of *Batrachiderpeton* resembles the new Batrachian in outline; that is to say, its length and breadth are about equal; but in that respect only does it resemble the new fossil cranium. The pre-maxilla of *Batrachiderpeton* is crowded with small conical teeth, while the pre-maxilla of the new specimen has not any small conical teeth, but their position is occupied by a small ridged pecten-like plate, which differs from any dental apparatus I have yet discovered or examined.

The vomer of *Batrachiderpeton* is covered with small rounded elevations, or teeth, and each side of the vomer is flanked with a row of eight teeth, nearly as large as are those on the pre-maxilla.

The vomer of the new Batrachian is adontoid, and with the exception of the maxilla, there are no indications of conical teeth on the under side of the cranium. The maxilla of *Batrachiderpeton*, so far as the figure of it gives any information, is without teeth, and in that respect it differs from that of the new Batrachian, inasmuch as between the positions marked *a*, *b*, a distance of $1\frac{1}{4}$ in., there are distinctly visible thirty-four maxillary teeth. The teeth are arranged at nearly equidistant intervals; they are small, glistening, and slightly striated. Those that are broken transversely show in their transverse sections relatively large pulp cavities, which are

filled with the white lime-like material usually found in the teeth and bone cavities of larger fossil reptiles and fishes. The cranium is fractured diagonally, as represented by the figure, and the posterior portion of the specimen is entirely absent.

A small portion of the outer surface of the cranium is exposed, and it presents the reticulated appearance which usually characterises the surfaces of the bones of the Reptiles and Labyrinthodonts of the Coal Period.

A NEW REPTILE TOOTH.

Figures 239[a] and 239[b] represent the front and side views of a reptile tooth, which is new to the Northumberland Coal Measures, and which is, I have reason to believe, new to science. The length of the tooth is $\frac{5}{8}$ in.; its width at the base is $\frac{3}{8}$ in., and its thickness at the base is $\frac{1}{4}$ in. Fig. 239[a] presents the front view, the tooth being curved forward as represented by the side view, fig. 239[b]. The tooth, near the apex, is tolerably smooth; but, from the base up two-thirds of the body of the tooth, there are a number of widely separated delicate grooves, and between the grooves there are broad, but not bold, convex ridges. The tooth, as seen in its side aspect, is considerably curved, and from its apex to about two-thirds along the body of the tooth, it is characterised by a peculiar form of cutting edge, the lanceolate character and form of which differ from the form and lanceolation of any other known teeth of Coal Measure Labyrinthodonts or Reptiles.

Anthracosaurus, *Loxomma*, *Streptodontosaurus*, and *Orthosaurus* have lanceolate teeth, but none of them resemble that being described. *Pteroplax*, the teeth assigned to which are pre-eminently doubtful, are lanceolate, but unlike that figured. *Amphisaurus*, *Leptognathosaurus*, *Batrachiderpeton*, and *Labyrinthodontosaurus* have circular teeth. The teeth of *Macrosaurus*, *Mesosaurus*, *Megalocephalus*, and *Amphi-*

cœlosaurus, are unknown, and these now named are the only large Labyrinthodonts or Reptiles yet found in our Northumberland Coal Measures. None of the vertebrata found in the Northumberland Carboniferous Strata have teeth that at all resemble that just described and figured.

FRAGMENT OF A JAW.

The annexed fragment or portion of a jaw, figured No. 240, has recently been found in the Low Main Seam, Northumberland; it contains two well developed and excellently exposed teeth. The sketch which accompanies this brief description is of natural size. The length of the specimen is $1\frac{3}{8}$ in.; the distance of the teeth from the posterior extremity, *b*, is $\frac{3}{4}$ in., and from the anterior extremity, *a*, is $\frac{1}{4}$ in. The teeth are placed in close contiguity to each other. They are $\frac{7}{16}$ in. long, and taper gradually from bases to apices. They are circular in form, and are marked from the bases upwards along one-half of their length, with deep grooves, the intermediate elevations being semi-circular. A thin film of the jaw extends up the bases of the teeth, and covers and dips into the longitudinal grooves. The dentary bone to which the teeth are attached is covered with exceedingly slight pittings. I feel considerable difficulty in interpreting this curious fragment, but think that the balance of probabilities points in the direction of its being the left half of a premaxillary bone, with two teeth near the point of symphysis, and with an entire absence of teeth in the direction of the proximal extremity.

CLIMAXODUS AND OTHER REMAINS.

There have recently come into my possession three specimens of fossils, all of which are, I believe, unique, and two of which are absolutely new to palæontology. They are numbered respectively, 241, 242, 243. No. 241 is a very

minute tooth of the little understood genus of Coal Measure fish known as *Climaxodus*, and is much smaller than any that have previously been discovered and described. The smallest teeth of *Climaxodus* previously described (and they have not the true Climaxodi form, but are somewhat Petalodontoid in appearance) are $\frac{3}{8}$ in. in length, while that now before me is $\frac{1}{8}$ in. long and $\frac{1}{10}$ in. broad; it is crossed by two well-defined ridges, has the distinct characteristics of a fully developed tooth of *Climaxodus*, and is, without doubt, the smallest specimen that has yet been described as belonging to our Northern Coal Strata, and is probably the smallest *Climaxodus* tooth that has yet been discovered in any locality. Fig. 241 represents the tooth magnified five diameters, and its resemblance to the larger Climaxodi will be made manifest by comparing the illustration with figs. 35, 36, 37, where a tooth of *Climaxodus* of natural size is represented.

The specimens figured 242 and 243 are both very difficult of interpretation. The former very closely resembles the posterior cranial bones at the base of a reptilian skull, and is probably a bassi-occipital of an Amphibian; *a*, *a*, being the condyles for the articulation of the axis, and *b* being the foramen for the passage of the spinal cord.

Specimen, fig. 243, bears a close resemblance to the sclerotic plates that are found surrounding the orbits of Liassic Icthyosauri, and of birds, but more especially of the eagle. The bones marked *a*, *a*, *a*, are slightly imbricated, and present the appearance of having been constructed for the purpose of expanding and affording protection to the eye. The specimen is unique, and was found unassociated with any other remains, so that it is impossible to do more at present than merely indicate similar kinds of osseous arrangement that are known to obtain in other animals, and leave the interpretation of the precise nature of the fossil an undetermined problem until additional discoveries shall afford the means of placing a proper and satisfactory interpretation upon it.

CRANIAL PLATES AND HEAD BONES OF CTENODUS.

Isolated cranial plates, and more or less isolated teeth of *Ctenodus*, have for the last few years been discovered in the Shale of the Northumberland Coal Mines; but until within the last few months associated cranial plates lying *in situ*, and bearing their natural relationship to each other, had not been discovered. We are now, however, in a position to speak with great certainty of the arrangement and classification of the cranial plates of that hitherto little understood fish. In the Ctenodi there are many apparent anomalies. The ribs, several of the internal head bones, all the external cranial plates, all the teeth and their supporting bones, are well ossified, while the vertebræ and some of the head bones appear to have been cartilaginous. There is little doubt of the fact that the vertebræ were cartilaginous, inasmuch as hundreds, nay, thousands of teeth, ribs, and head bones have been discovered in the Northumberland Coal Strata, and up to the present time not a single vertebral centrum has been found that can fairly be ascribed to *Ctenodus*. The superior internal head bones of *Ctenodus*, like those of the sturgeon, were probably cartilaginous, and they, like those of the modern fish referred to, were covered with strong, more or less imbricated, and irregularly joined bony plates, which covered and protected the skull proper of the Ctenodi, and are represented by figures 244, 245, and 246. An examination of those illustrations will show at a glance that, while there are minor differences in the forms and sizes of corresponding bones, there is a remarkable general resemblance.

The external bony plates which covered the probably cartilaginous skulls of *Ctenodus*, *Dipterus*, *Asterolepis*, *Osteolepis*, *Coccosteus*, *Diplopterus*, and other Devonian and Carboniferous fishes bear but a slight resemblance to the arrangement of the true internal cranial bones which form the skull proper of osseous fishes. All attempts to classify them, there-

fore, can only be approximate, and, following as closely as I am able the plan of classification furnished by Professor Huxley, I venture to indicate the following homological relationships of the three groups of bony plates already referred to. For ease of reference, I have marked the analogous bones in the three specimens illustrated of natural size, with the figures 1, 2, 3, 4, &c., and provisionally suggest the following as their probable interpretation: 1, supra-occipital: 2, frontal; 3, epiotic; 4, parietal; 5, post-frontal; 6, supra-temporal: 7, squamosal; 8, post-orbital. The arrangements of the cranial plates of *Coccosteus*, *Osteolepis*, *Diplopterus*, *Dipterus*, and *Asterolepis* may be seen by referring to pages 46 to 74 Hugh Miller's "Footprints of the Creator," by comparing which with the figures of the cranial plates of *Ctenodus*, now for the first time figured and published, it will be seen that there is considerable difference in the arrangements of the bones; the chief and most characteristic difference being the approximation of the occipital and frontal bones, the singleness of the frontal, and the separation of the parietal bones by having the occipital bone wedged in between them. The cranial plates of *Dipterus* perhaps most closely approach those of *Ctenodus*, but in *Dipterus* the parietals are between the occipital and frontal, and are in close contact with each other, while in *Ctenodus* the parietals are separated from each other by the width of the broad occipital plate. The average thickness of the cranial plates of *Ctenodus* is $\frac{1}{8}$ in.; their external surfaces are slightly pitted and corrugated, and they have a somewhat bright semigloss.

In addition to the head plates just discovered, I have recently had the pleasure of examining a splendid specimen of the teeth and head bones of *Ctenodus tuberculatus*, the property of Mr. John Salt, of Newsham. The specimen is represented of natural size by fig. 247. The letters *a* and *b* mark the upper surfaces of two palatal teeth; *g*, the bony connection between the two teeth; *d* is the anterior fractured extremity of the bone which unites the teeth; *a a*, and *a b*,

are the bony supports attached to the teeth; *c* is the rhomboidal expansion of the sphenoid bone; *e*, is the anterior extremity of the same, which is more than ordinarily produced, and *f* is the fractured posterior extremity. The form of a typical sphenoid bone of *Ctenodus* may be seen on referring to fig. 97, and a lower, or mandibular tooth of *Ctenodus tuberculatus* is presented by fig. 84. The appearance of the lower, or crushing side of tooth *a*, is represented by fig. 248, a^2; the tooth is crossed by eleven ridges, and each ridge is more or less tuberculated.

The following table of Coal Measure Vertebrata is given for convenience of reference, and information respecting the fishes, amphibia, and reptilia enumerated may be obtained in the preceding pages:—

NORTHUMBERLAND COAL-MEASURE VERTEBRATA.

SELACHIANS.

Gyracanthus.	*Cladodus.*
Pleuracanthus.	*Climaxodus.*
Diplodus.	*Pleurodus.*
Orthocanthus.	*Pœcilodus.*
Ctenacanthus.	*Leptacanthus.*
Ctenoptychius.	

GANOIDS.

Megalichthys.	*Gyrolepis.*
Archichthys.	*Cycloptychius.*
Acanthodopsis.	*Amphicentrum.*
Ctenodus.	*Palæoniscus.*
Strepsodus.	*Rhizodopsis.*
Cœlacanthus.	*Orthognathus.*
Acrolepis.	*Platysomus.*
Pygopterus.	*Dendrodus* (*?*)

AMPHIBIA. (LARGE.)

Anthracosaurus Russelli . . .	*Huxley.*
Loxomma Allmanni	*Huxley.*
Pteroplax cornuta	*Hancock and Atthey.*
Amphisaurus amblyodus . . .	*Barkas.*
Macrosaurus polyspondylus . .	*Barkas.*
Leptognathosaurus elongatus . .	*Barkas.*
Streptodontosaurus carinatus . .	*Barkas.*

AMPHIBIA. (SMALL.)

Urocordylus reticulatus . . .	*Hancock and Atthey.*
Ophiderpeton nanum	*Hancock and Atthey.*
Batrachiderpeton lineatum . .	*Hancock and Atthey.*
Mesosaurus Taylori	*Barkas.*

REPTILIA. (LARGE.)

Orthosaurus pachycephalus . .	*Barkas.*
Megalocephalus macromma . .	*Barkas.*
Labyrinthodontosaurus Simmii (?)*	*Barkas.*

In addition to the vertebrata just enumerated as discovered in the Northumberland Low Main Coal Shale, ichnitic impressions of the following genera have been found in the sandstones of the lowest carboniferous limestone formations, near Otterburn, Northumberland, viz. :—

Platytherium psammobates † . .	*Barkas.*
Tridactylosaurus Sandersoni . .	*Barkas.*

And the tooth of a new genus of fishes, in the shales of the carboniferous limestone formation, at Scremerston, near Berwick-upon-Tweed :—

Anthropodontoides Bailesii . .	*Barkas.*

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* It is doubtful whether *Labyrinthodontosaurus* be amphibian or reptilian.

† This may have been a mammal.

The vertebræ discovered by Mr. Taylor, in the new horizon of the High Main, I have named provisionally

Amphicœlosaurus Taylori . . . Barkas.

I have endeavoured to place before my readers brief and essentially popular descriptions, and correct illustrations, of the various fish, amphibian, and reptile remains that have been obtained by myself and a few earnest fellow-workers, from the collieries in the neighbourhood of Newcastle-on Tyne. My objects in preparing the foregoing chapters were to condense into a portable compass what has now been ascertained respecting the Carboniferous vertebrata of Northumberland; to stimulate palæontologists and persons who work in connexion with collieries to prosecute more vigorous researches for the vertebrate treasures that lie buried around them; and to enable investigators to interpret such fossils when they are fortunate enough to discover them.

Imperfect as I am conscious my labours are, I trust they may not be fruitless, and hope that some of my readers may be induced to search that vast volume of Nature many of the more interesting pages of which, in our Carboniferous formation, bear traces of the remains of large and small aquatic and terrestrial creatures that swam in the waters and roamed over the earth during that immensely remote period of the history of the world when our Coal Measure strata were deposited.

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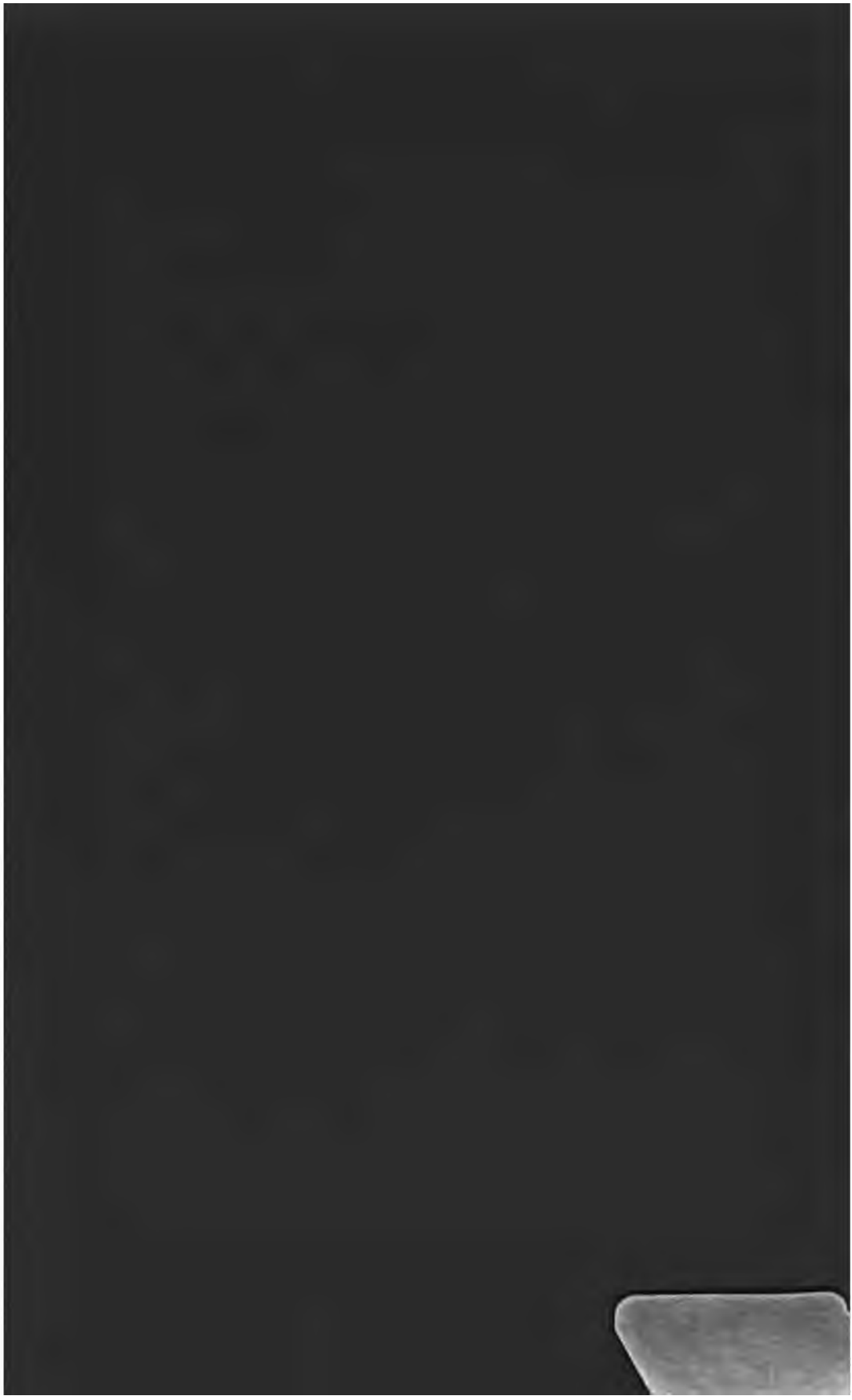

A MANUAL
OF
COAL MEASURE PALÆONTOLOGY

BY
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